POWER

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The A. S. M. E.

AN UNORGANIZED profession would come far short of realizing its possibilities for service, progress and development.

But it makes a great deal of difference how it is organized and what it is organized for.

Forty-six years ago the American Society of Mechanical Engineers was organized "to promote the Arts and Sciences connected with Engineering and Mechanical Construction."

Dr. R. H. Thurston, its gifted and far-seeing first president, said in his inaugural address: "The Society will have much work to do as a union of citizens having important interests confided to them, and its province will lie no less in the field of social economy than in that which has reference only to the individual interests of its members."

How well the purposes of its founders are being carried out will be evidenced by the meeting which was held last week, the program of which contains, in addition to a long list of papers dealing with the technique of the profession, a conference upon a question of such broad public moment as Smoke Abatement, the Effect of Smoke on Health by an eminent member of the medical profession, a session devoted to the possibilities of more refined methods of utilizing coal than burning it, with all of its valuable constituents, raw.

In addition to the address of the retiring president the opening session was signalized by the award of the John Fritz Medal upon one of the honored members of the Society.

Bordering the field of mechanical engineering on the one hand is that of pure science, and on the other that of economics; and following its recently established practice the Society presents annually a formal lecture in both of these fields by specialists of national reputation.

The annual dinner was made the dignified and impressive occasion of the induction of those who have joined the Society during the year.

Concurrently with the meeting of the Mechanical Engineers, the American Society of Refrigerating Engineers was in session, and the Power Show open. The program was interspersed with meetings, conferences and hearings of the Council and numerous sections and committees.

To one who followed the program the week was an impressive demonstration of what organization is effecting for the mechanical engineer.

F. R. Low

A.S.M.E. Holds Forty-Seventh Annual Meeting

Extensive Technical Program and Good Fellowship Mark Gathering— Charles M. Schwab To Be New President— John Fritz Medal Awarded

THIS year's Annual Meeting Program of the American Society of Mechanical Engineers was replete with information appealing to the problems of the power engineer, and the attendance at these sessions reflected strikingly the wide interest in this particular field. Among the subjects discussed were industrial power, central-station power, coal carbonization, smoke abatement, heat transmission, oil and gas power, and feed-water treatment. There was also a joint session with the American Society of Refrigerating Engineers.

Following so closely upon the recent International Conference on Bituminous Coal at Pittsburgh, the fact that a whole session at the A.S.M.E. meeting was devoted to the byproduct processing of coal is indicative of the growing importance of the subject in this country. Moreover, the Robert Henry Thurston lecture on Tuesday afternoon was given by Dr. Cecil H. Lander, Director of Fuel Research, Department of Scientific and Industrial Research, London, England, who chose as his subject "Recent Developments in the Science of Coal Utilization."

Importance of Safety Urged at Each Session

Five minute talks on safety were given at each of the technical sessions. These were delivered by: A. J. Van Brunt, directory of safety education, Public Service Corporation of New Jersey, Newark; C. W. Price, Elliott Service Corporation, New York City; D. J. Price, Bureau of Agriculture, Washington, D. C.; Charles E. Hill, general safety agent, New York Central Railroad, New York, N. Y.; S. H. Libby, General Electric Company Bloomfield, N. J.; G. E. Sanford, General Electric Company, Schenectady, N. Y.; G. C. Agry, The Lamson Company, Syracuse, N. Y.; L. A. DeBlois, National Bureau of Casualty & Surety Underwriters, New York; A. W. Whitney, National Bureau of Casualty & Surety Underwritors, New York City; R. B. Grove, United Elec. Light & Power Co., New York City; L. Hatch, New York State Dept. of Labor, New York City; C. S. Ching, U. S. Rubber Co., New York City; Lew Palmer, Equitable Life Assurance Co., New York City; George A. Orrok, consulting engineer, New York City; Ray S. Bonsib, Standard Oil Co., New York City.

So far as the social features of the Meeting were concerned, the plan of the last two or three years was closely followed. This included an open-house at the Societies Building on Monday evening, which was enlivened by a farce, based upon an investigation into the cause of a hypothetical boiler explosion, during which several members qualified as expert witnesses in a humorous vein.

Preceding the presidential reception on Tuesday evening, President Abbott delivered his address (to be found elsewhere in this issue), and the occasion was further marked by the presentation of the John Fritz medal to Elmer Sperry, for his work in the development of the Gyro-compass and applications of the Gyroscope.

Charles M. Schwab, the incoming president, was introduced and made a few fitting remarks, in which he recalled his earlier years, devoted to engineering, as the happiest period of his career.

Mr. Schwab was the principal speaker at the annual dinner at the Hotel Astor on Wednesday evening. His remarks were extemporaneous and included a number of stories and personal reminiscences, which were heartily received. He told the members of the Society that as their president he would follow the principles that have guided him in the past, namely, that good-natured hearty co-operation is the success of any enterprise and that the man who has the ambition to gain the fellowship of his associates is bound to succeed.

"I have preached democracy all my life," he said. "The aristocrat of today is not the man of birth or social position, but the man who does something for the benefit of humanity. Nor is money everything, for there comes a time when it means little. But the appreciation of fellow-workers lasts always."

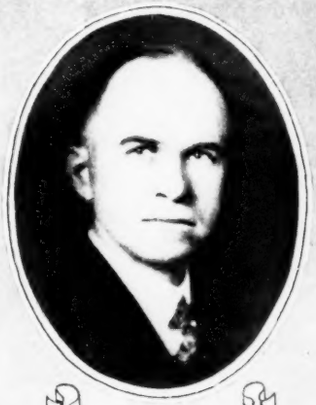
Admiral Earle Receives Scott Medal

The dinner was made the occasion for the presentation of the John Scott medal to Admiral Ralph Earle, president of the Worcester Polytechnic Institute and formerly chief of the Bureau of Ordnance, for his invention of the fourteen-inch naval railway gun mounts and of the mine barrage across the North Sea during the war. This award consisted of a medal and a cash prize of $1,000, under a bequest made by John Scott of Scotland in 1816, and administered by the Board of Trusts of the City of Philadelphia.

The attendance at the dinner closely approached 1,000 and included a number of new members who were fittingly welcomed by Past-president Durand. Three of these members were ladies.

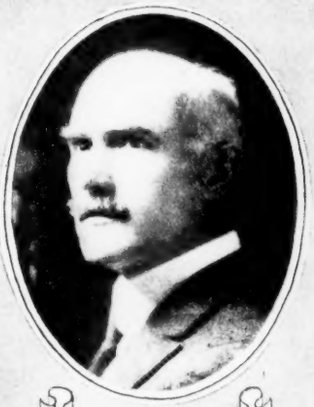
Among the more important excursions were visits to the new Kipp's Bay Station of the New York Steam Co., to the new East River Station of the New York Edison Co., to the Harrison Gas Plant of the Public Service Co. of New Jersey, to the Holland Vehicular Tunnels, to the Hudson Avenue Station of the Brooklyn Edison Co., to the Hell Gate Station of the United Electric Light and Power Co., and to the plant of the De La Vergne Machine Co.

Newly Elected Officers of the A.S.M.E.



EVERETT O. EASTWOOD
Vice-Pres.

CHARLES L. NEWCOMB
Vice-Pres.



EDWARD R. FISH
Vice-Pres.

CHARLES M. SCHWAB
President

RALPH E. FLANDERS
Manager

CONRAD L. LAUER
Manager

PAUL DOTY
Manager

The Changing Relations Between Employer and Employee

By WILLIAM L. ABBOTT

Abstract of Presidential Address to A.S.M.E.

THE civilizations of the past, with their diversified achievements of wealth, learning and culture, benefited, mainly, the favored few, but rested basically on the shoulders of the enslaved masses. With the growth of wealth and power for the privileged classes the gulf of inequality across which the laborer toiled unceasingly for a meager existence in return, widened and deepened until the ratio of the numbers of slaves, serfs, thralls, peons or bondmen under other names to the numbers in the master class may be taken as ranging from one to six, varying, of course, with the age and with the country.

Compare the condition of that patrician of the olden days, surrounded by his slaves, with the standing of the American workman in this day of steam and electric power. This modern patrician, with his mechanical aids before him, has at his hand and command an amount of power equal to the strength of scores of tireless slaves of the greatest skill, willingness and discipline. As the slave of the past brought to his master wealth and, in its train, ease, learning and culture, the slaves of the present-day American toiler are making him the richest workman the world has ever seen, and these riches, too, are bringing their gifts of pleasure, comforts, education and culture.

William L. Abbott

This present situation is a comparatively recent outcome of a series of slow changes in the relations of employer and employee since the time when the manufacturer worked with members of his family in his home or in his small shop near-by. Sons and daughters were trained in the crafts of their parents or bound over in apprenticeship to another family to learn and to produce, and to share not only in the long, hard work and small pay, but in the sentiment and society of the home as one of the family.

The shop continued to grow until it surpassed the ability of the master and of his friends to finance, steam was harnessed, and machinery perfected. Then slowly came the inevitable corporation, which separated by miles master and men, who already had drifted far apart. Executive cares engrossed their old-time friend and companion. Foremen and superintendents intervened, and while the company and its officials were visibly prosperous, the men had no seeming part in that prosperity. Long hours, hard labor, small pay and miserable conditions were not to be endured under the corporation. Periods of depression, unemployment and resulting evils gradually caused the workmen to feel that they had been abandoned to the exploitation of the controlling few. In self-protection the men sought to slow down their production. Mass action and war was necessary, and so the union was brought into being. Employers fought fire with fire and vengeance with vengeance. The tide rolled back and forth across industry and society; both lost and both won.

The sympathetic relations born in the family group in the workshop of early centuries were slowly reconditioned on broader, surer lines. Intimate social contact was, of course, no longer desired or possible, but the right of the workingman to be respected as a man and not treated as a machine, and to have the privilege of making suggestions not only in his own interests, but for the betterment of the work of the shop and of the general good of the company, was now not only granted but desired by his employer. So then, owing to his financial and friendly interest in his employing company, the workman's former policy of doing as little as possible is now changed to one of doing all he physically can.

A few months ago the industries of this country and of Great Britain listened with attention to the report of a delegation of British trade unionists, sent to this country to investigate at first hand and to discover and report upon the secret of the prosperity of American industries and the high wages paid to American workmen, at a time when English industries were depressed and there was so much unemployment among their workmen.

The Mission, as it was called, spent six weeks in America, visited several cities, and examined carefully into the workings of forty-two shops, talking freely with superintendents and workmen, and upon their return home each of the eight members of the Mission made an independent report of his findings and impressions. All reported excellent feeling between employer and man.

Six of them say directly that the cause of American prosperity is high wages. All comment on the cordial, even friendly, relations existing between management and men, and the absence of lines of demarcation between the two groups. All comment on the high rate of production of the workmen, with earnings in propor-

tion, and the eagerness on both sides to speed production to still higher rates with still higher pay.

The building trades, from their very nature, easily lend themselves to unionization. Their work must largely be done locally, and it is done but once for a single owner. The added cost due to union domination and union conditions is much less than the cost of union opposition and strike delays. Hence the inclination to proceed with the work, in full realization that often the labor costs will be from two to three times as high as they would be with non-union labor at the same hourly rate, all due to the policy of making more days' work for working men out of any given job.

Whatever may be the policies of coal operators at the present time and however just and liberal may they be in their dealings with their employees, they cannot in one, two or three decades erase the memories of the wrongs and indignities perpetrated by grasping mine operators upon ignorant and unorganized miners, who were at last aroused to rebellion against their oppressors, and following victory the imposition of humiliating conditions upon their employers, some of which unwise conditions contained the germs of elements which would in the end cause the disintegration of the very organization under whose banner they obtained their freedom.

An equitable distribution of the savings to be realized from the installation of labor-saving apparatus would be a substantial increase in the employee's pay envelope and a decided reduction in price to the consuming public, while the employer, after receiving an amount sufficient to warrant the additional investment, would benefit principally by the increased business which would result from the reduction in cost of the product.

The Dawn of a New Order

But there is great promise that a new order of things is about to dawn, and as already millions of workers are employed under conditions which provide for frank interchange of views and all cordially unite to deliver to the public the best product at the lowest consistent cost, it may be said that the new order of things is here—the reconciliation of capital and labor.

Our present condition of labor not having been brought about through the intervention of those who professionally pose as the champions of workingmen, is regarded by them as a menace to the institutions and theories which they represent, and already threats are heard that this new cordial direct relation between workmen and employer shall be disrupted, that they and their influence may intervene. What is the outcome to be? The answer is largely in the hands of operating and superintending engineers.

The Part of the Engineer

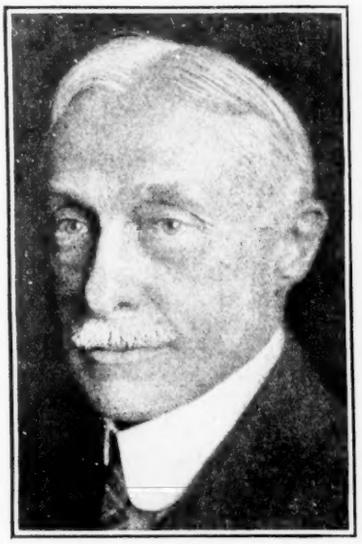
You have carefully studied the characteristics of the materials you employ, that your treatment of those materials may best adapt them to the service of mankind. Have you been as considerate of the characteristics of the human bodies that enter so largely and vitally into your products?

When we fully realize that industrial relations are a major and not an incidental problem of production and that the employee's co-operation, welfare, self-respect, ways of thinking, and humors are major ingredients of success, and when we respect and use them accordingly, then we may visualize another statue lighting the way to industrial freedom, prosperity and peace.

Elmer A. Sperry Presented John Fritz Medal

SIGNALIZING a long career studded with numerous achievements in practically all branches of engineering, presentation of the John Fritz Gold Medal for 1927 was made to Elmer A. Sperry at exercises held in his honor the evening of Dec. 7 by the John Fritz Medal Board of Award, representing allied societies, in connection with the annual meeting of the American Society of Mechanical Engineers.

The award, bestowed more particularly for Dr. Sperry's development of the gyro-compass and the application of the gyroscope to the stabilization of ships and airplanes, was fittingly marked by short addresses in appreciation of the medalist by Robert Ridgway, chairman of the Board of Award and past-president of the American Society of Civil Engineers, William L. Saunders, Naval Consulting Board of the United States, and Frank B. Jewett, past-president of the American Institute of Electrical Engineers, Mr. Jewett making the presentation.



Elmer A. Sperry

"Descriptions of Mr. Sperry's many contributions to the advancement of the naval arts cannot be compressed into a brief statement," wrote Rear Admiral Bradley A. Fiske, summing up Doctor Sperry's marine inventions. He is a real inventor. Many persons who have been called inventors have only devised improvement or adaptations. Sperry is a man of actual originality. He has made true discoveries and brought them into the realm of the mechanical arts and utilized them for the benefit of mankind."

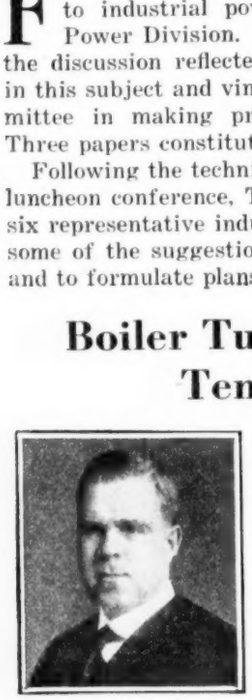
Speaking of Doctor Sperry's work for the Naval Consulting Board and in mining, W. L. Saunders, president of the United Engineering Society, lauded the medalist's versatility, resourcefulness, indefatigability and broad knowledge of science and engineering as of inestimable value to the nation in World War. His valuable contribution to the peaceful arts are many.

Industrial Power Looms Important

FOR the second time a whole session was devoted to industrial power, under the auspices of the Power Division. The attendance and character of the discussion reflected the large membership interest in this subject and vindicated the judgment of the committee in making provision for a separate session. Three papers constituted the program.

Following the technical session there was an informal luncheon conference, Tuesday noon, attended by thirty-six representative industrial power engineers to discuss some of the suggestions made at the morning meeting and to formulate plans for carrying on the work.

Boiler Tubing at Elevated Temperatures



A. E. White

EVEN though the experimental work is not complete, because of its immediate importance, Prof. A. E. White and C. L. Clark, in a joint paper discussed their results on the properties of boiler tubing at high temperature.

The investigation was carried out on 0.13 per cent carbon-steel seamless tubing, exposed to temperatures as high as 1,500 deg. F. The tubing was subjected to both a straight tensile test to determine the proportional limit, the tensile strength, and the elongation; and to an internal pressure test.

As a result of the tensile tests it was found that the tensile strength increases up to 500 deg. F. and then decreases rapidly. The proportional limit decreases continuously as the temperature is raised. The elongation decreases to 500 deg. F. and then increases rapidly.

In the internal pressure tests, failure was assumed imminent when the diameter started to enlarge. At 1,500 deg. F. an internal pressure that would cause a tensile load of 106 lb. per sq.in. was maintained 540 hours without expansion, although in time the tube would have failed from oxidation. At 1,250 deg. F. the tube would not satisfactorily withstand an internal pressure corresponding to a tensile stress as low as 213 lb. per sq.in. Between 1,000 and 1,250 deg. F., however, there is a sharp decrease in strength.

At these temperatures the proportional limit resulting from the straight tension test was found not to be the criterion of stability, as it indicates a possible tensile stress much higher than the material will permit without showing enlargement due to internal pressure.

Discussion of Professor White's Paper

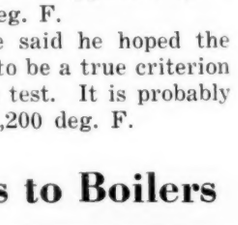
In discussing this paper, H. S. French suggested that there is a relation between the load capacity and the proportional limit. He believes that the proportional limits above 1,250 deg. F. are inaccurate and is unable to accept the implied conclusions.

J. N. Laselles agreed regarding the proportional limit which he felt was difficult to determine.

G. B. Carowitz criticized the formulas that had been derived as dangerous in that they give the impression of unjustified generality. The formula applied only to the specific data found for 1,250 deg. F.

In his closure, Professor White said he hoped the proportional limit would be shown to be a true criterion as there was need for a short time test. It is probably all right for temperatures up to 1,200 deg. F.

Relation of Stokers to Boilers



W. A. Shoudy

PREFACING his paper with a brief review of stoker development, W. A. Shoudy[1] showed that for years the preponderance of inclined straight-tube boilers were built 14 tubes high. Additional surface was obtained by increasing the number of tubes vertically. This gave a cheaper boiler per square foot of surface but no larger stoker could be fitted under it than under a 14-high boiler. Consequently, no greater steam output could be developed nor could the stoker be operated at a higher rate of combustion or higher furnace efficiency. Because the heating surface was larger, the exit gas temperatures were lower, hence the combined efficiency of the higher boiler exceeded that for the 14-high boiler for the same steam output.

The 20-high boiler or its equivalent is now common and a few 24 tubes high are in operation. A 4-in., 20 ft.-tube boiler, 18 tubes wide, will have a heating surface, depending upon the number of tubes high, approximately as follows: 14-high, 6,200 sq.ft.; 20-high, 8,400 sq.ft., and 24-high, 10,000 sq.ft. The same size stoker will fit under each. If a stoker is selected for the first boiler which will permit of operation at 400 per cent rating, 2,480 hp. will be developed. If the first boiler is replaced by one 20-high and neither the coal nor the stoker changed, no greater output can be obtained and the maximum rating for this combination will be 295 per cent. If the 24-high is next substituted, only 248 per cent rating can be obtained since the furnace conditions are the same in all three installations. The furnace efficiency will be the same for all, but the combined efficiency will be the highest with the 24-high installation because of the lower exit gas temperature.

The term "per cent of rating," where applied to present day boiler operation, is of little value unless the design of the boiler is specified. For example, when comparison is attempted of tests on the Hell Gate boilers and the new Interborough boilers. The former have 3 in. tubes whose surface approximates a 12-high, 4-in. tube boiler. The Interborough boilers are 24 tubes high. The ratio of heating to grate surface in the latter is approximately double that of the former. The tests reported by Mr. Reynolds of the Interborough R. T., show-

[1]Associate professor of Mechanical Engineering, Columbia University and Advisory Engineer, General Engineering & Management Corp.

ing 343 per cent rating, represents a furnace condition approximating 585 per cent rating on the Hell Gate boilers, whereas the highest reported rating on the Hell Gate boilers, 590 per cent as reported in *Power*, is the equivalent of 295 per cent rating on the Interborough boiler.

This shows how little value are comparisons on the basis of per cent of rating. Intelligent comparison between such two widely separated installations can be made by comparing the stokers on the basis of pounds of coal or B.t.u. liberated per square foot of grate area (actual or projected) and the boilers on the basis of evaporation per square foot of heating surface or per foot front of boiler furnace.

Operating difficulties at high ratings are due to one or more of the following causes:

1. Impure feed water.
2. Poor circulation or insufficient steam liberating surface.
3. Restricted feed water supply.
4. Grate or stoker trouble.
5. Ash or clinker trouble.
6. Refractory trouble.

The first three can be foreseen and either eliminated before they occur or the installation limited to a conservative rate of evaporation.

Before the type of stoker can be selected the character of the coal must be known according to the following classification:

1. Relative ease of ignition.
2. Per cent of ash content.
3. Fusion temperature of the ash.

Anthracite is hard to ignite, and ignition is difficult to maintain. The finer sizes can best be burned in thin fires and when not agitated. The chain grate makes possible a thin fire without agitation, as well as a continuous dump for the relatively larger ash content. Refractory arches for maintaining ignition can be installed without difficulty. Coke breeze offers generally the same difficulties, though some qualities have been burned successfully on underfeed stokers.

The Eastern bituminous coals, with their higher volatile content and generally low ash, seem to have been created for the underfeed stoker. The fusing temperature of the ash is generally above 2,400 deg. F., offering little clinkering trouble, and the highest combustion rates are easily obtained.

Moving westerly into the fields of higher ash content and lower ash-fusion temperatures, the underfeed-stoker troubles begin. The continuous ash discharge or clinker grinder must be substituted for the dump plate because of the larger quantities of ash that must be removed, and a lower rate of combustion must be selected so that the fire-bed temperature may not be sufficient to fuse the ash and cause clinker trouble. Chain grates are an active competitor in these territories because of their continuous dumping action and the generally lower rates of combustion and thinner fire.

Another ash trouble is that due to the molten fly-ash which passes into the boiler surface, adhering to the tubes and restricting the gas passages. This trouble varies with the coal and the rate of combustion. Some improvement has been accomplished by leaving out alternate tubes in the lowest row or rows, thus eliminating bridging from tube to tube. Some of this fly-ash, on reaching the colder space between the tubes, is chilled and drops back into the furnace or passes through the boiler as hard ash. Preheated combustion air has helped in some cases and not in others.

For many years refractory failures were laid to too low a grade of firebrick or too high a furnace temperature, but it has become common knowledge that the chemical composition of the ash is just as large a factor in furnace design. Much of the erosion of the firebrick can be laid to the fluxing action of the molten ash, especially those of low fusing temperature Brick that will successfully perform with one coal will not with another because molten fly-ash washes away the brick until the wall fails or a state of equilibrium is reached when the heat radiated from the brick is sufficient to cool the surface to the congealing temperature of the ash. This trouble is more pronounced with pulverized coal than with stokers. The solution seems to be that of cooling the wall either by air or by water cooling.

The problem of selecting the correct boiler and stoker combination becomes one of selecting first the stoker and furnace and then selecting the best heat-absorbing surface that price of fuel, draft, use factor and fixed charges will permit.

The size of the stoker will depend upon the quality of the coal and whether money can be spent for water- or air-cooled walls. It is doubtful whether water-cooled walls can be justified for boilers smaller than 7,500 sq.ft. except possibly to patch at the base of the bridge wall or when the fluxing of the ash is unusually severe. Without water cooling 60 lb. of coal per square foot of projected grate area should be the maximum for underfeed stokers. With complete cooling 75 lb. may be used, but in either case 35 to 50 lb. should be the rate for best operation. Preheater air may improve these rates, although complete data are lacking and higher rates cannot be counted upon at present. With anthracite, 55 to 60 lb. should be considered a maximum and the best rates taken as 30 to 45 lb. The higher rates will give capacity, but at the expense of loss of fine coal to the chimney.

The Discussion

W. H. Jacobi, of the Springfield Boiler Co., in discussing Mr. Shoudy's paper, stressed the necessity for a comprehensive set of definitions to designate boiler performance. These should provide a sound relation between the function of the boiler and that of the fire. He was glad to see such terms as "boiler horsepower" and "per cent of rating" gradually going out of use, and pointed out that there is little relation between heating surface and boiler capacity, the latter depending on the amount of fuel that can be properly burned under the boiler. He saw little merit in extremely high rates of forcing, and believed that inasmuch as operation at a constant load is seldom attained individual stacks are usually better. High stacks operating on fractional loads result in high initial drafts in the furnace, which by inducing localized high combustion rates and high velocities, may lead to furnace damage and perhaps unsatisfactory performance. The importance of high CO_2 was, in the speaker's opinion, overestimated. He believed that instead of using the term pounds of coal burned per square foot of grate surface, it is better to state the permissible rates of combustion in terms of B.t.u. liberated per unit area of effective stoker service.

H. S. Bacon of the Westinghouse Electric & Manufacturing Co., urged that fuel-burning equipment and the boiler be chosen together and correlated. He believed it possible to set a boiler too high and that the

furnace volume is not the determining factor. The height of furnace should be governed by the fuel and flame length; that is, the boiler should be placed as close to the stoker as the maximum flame length will permit. Too little study of clinker and ash has been given from the chemical viewpoint. Iron in the ash is responsible for most of the troubles, and trivalent iron is less harmful than bivalent. The fusion temperature of ferrous elements are lower than ferric. Preheated air has not brought about troubles that had been anticipated; in general it has produced better fuel-bed conditions. With preheated air Midwest coals can be burned with results comparable with Eastern coals.

N. E. FUNK, of Philadelphia, backed up the previous speaker's remarks by quoting from the experience of the Philadelphia Electric Co., where preheated air had not resulted in any troubles. He believed, further, that more attention should be given to the designing of furnace walls; that this is more a problem of heat absorption than heat insulation. The solid refractory wall he believed to be a thing of the past.

R. S. BAYNTON told of his experience at the new high-pressure plant of the Chesapeake Corporation at West Point, Va., which is operating with highly preheated air (200 to 400 deg.) supplied by three 5,000-sq.ft. boilers. The stack temperatures range from 250 to 300 deg. and the CO_2 averages about 13½ per cent. These results are obtained with a high-grade 14,500-B.t.u. coal, containing 78 per cent carbon and 5 per cent ash. Much less refractory trouble has been experienced than with the old boilers not employing preheated air.

Power Station Accounting for Industrial Plants

A COMPREHENSIVE system of power station accounting, as employed in seven plants of the General Electric Company, was outlined in a paper by William R. Herod. The system is especially applicable to large industrial plants, where the cost of power, although perhaps only a small part of the manufacturing cost, represents a large sum in dollars. The boiler plant is treated as an independent production department, and the cost of steam accurately determined. This is then charged at cost to the various departments and services such as electric power, manufacturing departments for process, heating, etc. The steam charges are then added to the other charges, properly allocated to the individual services, so that a total cost for each service is ascertained. The unit adopted is 1,000 lb. of steam from and at 212 deg.

Such a system has an advantage over a blanket method of billing for power, heat and light, in that it not only insures each department being properly charged for the service it uses, as determined by the various meters, but it also enables the management to check waste and fix responsibility. Furthermore, it affords a means of comparison of economies as between plants, and provides useful data for future extensions or replacements.

Columns for calculated debits and credits are included in the report form. For instance, a non-condensing turbine is credited with the exhaust steam returned and a unit may be debited for condensate temperature above normal. The difference between the debits and credits for any individual machine or service represents the net consumption of that particular machine.

The fundamental thermal data for the determination of these debits and credits are derived principally from the total heat of the steam supplied as measured above the general condensate temperature, that is, above the average temperature at which the drips, makeup and condensate are returned to the system before reaching the feedwater heater. No account is taken of the minor differences in heat consumption due to the various services returning condensate and drips at other than the general condensate temperature, but it was felt that to record the temperature of returns from each of the various services was a refinement not warranted at the present time.

This and other operating information is contained on a comprehensive engineer's report, a sample of which the author included. In addition to the engineer's report is another prepared by the accounting department, containing a report of costs and expenses, and the distribution of them to the various services. These costs include that of coal, water, labor, maintenance, depreciation, insurance, taxes, etc., and are tabulated for the individual services. In this way the steam charges are first determined and the allocation of the steam costs to the various services, such as electric power, process steam, etc., is then effected according to the distribution prepared by the plant engineer and indicated in the engineer's report.

A third, or comparison, report is prepared by the main office of the company, showing relative performance and costs as between the several plants. These three reports constitute an accurate comparison of the economies and costs of the various power stations considered.

DISCUSSION OF POWER STATION ACCOUNTING

GUY B. RANDALL of the National Cash Register Co., Dayton, Ohio, suggested that the A.S.M.E. devise a plan or code for power-plant records, which would afford a common yardstick for the comparison of performance of industrial plants. This would get away from personal systems and establish a simple uniform method that any executive could understand. The speaker suggested that the year be divided into four thirteen-week periods rather than four- and five-week months; also, that, in order to avoid misleading figures as to performance of units supplying different services, they all be rated in terms of kilowatts.

M. K. BRYAN, of Boston, was of the opinion that Mr. Herod's system was too complicated to be applied generally, and believed that a simple system might be got up to disclose existing wastes in power plant operation. He cautioned that in making comparisons as between the performance of different plants, the difference in design efficiency should be taken into account. Also, while it is true that in many industries the power cost represents only a small part of the production cost of the manufactured product, still it often represents a very considerable percentage of the net profits available for dividends.

H. M. BURT, of the Mount Hope Finishing Co., had found that it is not always feasible to show thermal values to the management, but that these should be translated into terms of dollars per unit of production. Moreover, it is desirable to break up the problem into its component parts; namely, power production, distribution and utilization. This permits segregating waste, which is frequently found to be more in utilization than in the production of power.

Heat Transmission Discussed in Joint Session with A.S.R.E.

TUESDAY afternoon the A.S.R.E. joined with the A.S.M.E. in discussing the question of heat transfer in connection with refractories, pipe insulation, and building insulation. More important, possibly, than the new material presented was the obvious effort to co-ordinate the work being done to avoid duplication and render more effective the efforts of the large number of experimenters working on this subject. The program was arranged by the Committee on Heat Transmission of the National Research Council.

Conductivities of Insulation up to 1,000 Deg. F. on Other Than Flat Surfaces

R. H. Heilman

IN ORDER that others may profit by his long experience in experimentally determining thermal conductivities of insulations, R. H. Heilman, in his report to the National Research Council, details a method of test procedure. This is done in an effort to make more useful the large amount of work which is being continually carried on in this field, but which usually quotes over-all coefficients suitable for one set of conditions only and does not determine the thermal conductivity of the material itself which is of much broader significance.

Components of Temperature Drop

The temperature drop from an insulated steam line to the surrounding air is made up of five distinct items:

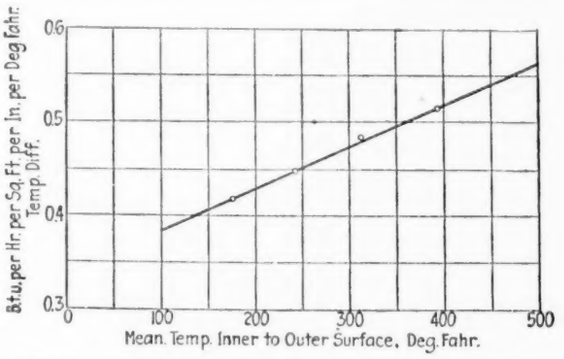
1. Drop from the steam to the inner surface of the pipe.
2. Drop through the pipe wall.
3. Drop from the outer surface of the pipe to the inner surface of the insulation.
4. Drop from the inner surface of the insulation to the outer surface of the insulation.
5. Drop from the outer surface of insulation to the surrounding air.

With regard to the first-temperature drop the author is of the opinion that 10 deg. F. is amply sufficient with superheated steam flowing through an insulated pipe. With superheated steam this drop in temperature is slight.

The drop in temperature through the pipe wall is small and in general can be entirely neglected, either in calculations or measurements in the testing apparatus.

The drop in temperature from the outer surface of the pipe to the inner surface of the insulation depends upon the resistance to heat flow introduced by the intervening air space. Thus this temperature drop will vary with the kind and thickness of the insulation, the diameter of the pipe, the thickness of the air space and the nature of the surface of the pipe. Experiments conducted make it evident that it is impossible to predict accurately this temperature drop.

In determining the drop in temperature through the insulation, the temperature at the outer surface can be measured very accurately. The temperature at the inner surface, on the other hand, and the temperature



Absolute conductivity of covering 0.98 in. thick on 3-in. pipe

gradient through the insulation is difficult to measure. The author has found that the conductivity of all insulations he has tested varies with the temperature difference according to a straight line law. And, when this is the case, the temperature gradient is unnecessary for the equivalent conductivity for the whole thickness is equal to the conductivity corresponding to the arithmetical mean of the two surface temperatures.

Drop Between Insulation and Air

The drop in temperature between the surface of the insulation and the surrounding air has already been discussed by the author and an equation given for canvas-covered pipe insulation on horizontal pipes in free air. This is reported in *Mechanical Engineering*, Vol. 46 (1924) No. 10, p. 593.

The thermal conductivity of the insulation involves the drop in temperature through the insulation alone, although for convenience in measuring, this drop in temperature is assumed to be equal to that from the outer surface of the pipe to the outer surface of the insulation. The temperature of the pipe surface is measured by thermocouples embedded in the surface, and the temperature of the outside surface of the insulation is measured by thermocouples placed under paper labels.

The arrangement of the apparatus, either a section of pipe for testing pipe insulation or a spherical ball for testing cements, is described in detail by the author. The heat flow is measured by the input to properly arrange electric heaters and, in testing the pipe insula-

tions, precautions are taken to nullify the effect of the end conditions.

It is best to give the absolute conductivity of the covering because this quantity is basic, varying only with the material. This absolute conductivity is the heat flow in B.t.u. per hour per inch of thickness per degree Fahrenheit temperature difference and is found for pipe insulation by the equation.

$$K = \frac{H\, r_1 \log_e \frac{r_2}{r_1}}{t_1 - t_2}$$

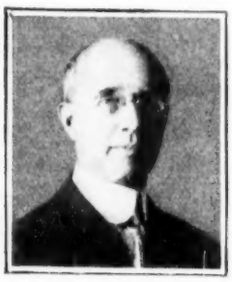
where

H = Heat loss per sq.ft. of pipe surface;
r_1 = Radius of the inner surface of the covering (taken as the outer radius of the pipe);
r_2 = Radius of the outer surface of the covering;
t_1 = Temperature of the inner surface of the covering;
t_2 = Temperature of the outer surface of the covering.

The accompanying illustration shows for a typical case, the variation of the absolute conductivity with the mean temperature.

At the end of the paper Mr. Heilman gives a valuable bibliography of the subject with a synopsis and criticism of each reference.

Heat-Transmission in the Refractory Field



P. Nicholls

THE object of this report by P. Nicholls, like the one by Mr. Heilman, is to picture the field and research methods in the study of refractories to give the future investigator both the benefit of past results and a clean conception of future needs in the work, thus pointing the way to more effective research. The article is apparently written at the request of the National Research Council.

This field of heat transmission deals with non-metallic materials which are used in connection with temperatures in excess of 1,000 deg. F. Research in refractories has become important during recent years because efforts to procure increased and more economical production have tended to raise the temperatures used in manufacturing operations, and the limit is often fixed by the ability of the refractory to last an economical period.

High-temperature materials may be divided into three classes according to use: First, materials that are used for heat insulation and are not subjected to the highest temperatures, but are placed on the cooler side of the true refractory part of the furnace. Secondly, true refractory materials, which can be subjected to the furnace conditions. These may be used either to surround the furnace or to transmit process heat, at the same time holding or supporting the process materials. Thirdly, the process materials themselves, such as ores in wasting or smelting, clays during burning, coal during coking, etc., about which heat-transfer data are desirable.

The first group and the first part of the second group can be treated together as a heat-flow prevention class. Most of the research work has been done on this class in connection with studies to see if this heat loss would be reduced. For this class to obtain the desired results, it is necessary to know the thermal coefficients of the material, the furnace-wall inner face-temperature, and how to translate a cycle of operation into a true mean.

The materials in the second part of the second group should permit rather than retard heat flow. Very little work has been done on this phase, which is more intricate because of the heat transfer into the process material with which it is in contact. In the past, experience has been considered the best teacher, although there is evidence that this is changing and that more definite knowledge is desired.

The heat transfer to and the flow through aggregates involved in the third group has probably been studied to various extents by trades concerned. There is no reason, however, why more fundamental data should not be available, especially for materials that are not changed by heating.

The most definite data existing cover the thermal properties of refractory materials; namely, their thermal capacity, conductivity and diffusivity. And results on the same material by different experiments differ by as much as 100 per cent. In this connection Mr. Nicholls concludes that it would seem desirable that the initial study should be on one material in all its possible physical forms. Furthermore, it would seem very desirable to have available some one material whose uniformity and similarity in different samples is so assumed that it could be used by investigators as a common check piece for comparisons of methods. The final test of the accuracy is that results in service should agree with those predicted from laboratory tests. Any plan of attack should include the measurement of the flow in service of the same refractories as tested in the laboratory.

There also appears to be a need for experiments to determine radiation constants for gases with various compositions, and carrying solids and burning particles. This data can probably best be obtained from actual furnaces.

In furthering this work, a central committee, well acquainted with the industries, could perform a valuable service. It could be in touch with the work going forward, and with the aspirations to make observations, and would thus be in a good position to co-ordinate it, save the time and money of the investigators and adapt the results to the most useful form for others.

At the end of the article the author gives a bibliography including an abstract of each reference and critical notes to assist the reader in classifying each.

A Practical Method of Figuring Heat Transfer

IN COMPARING the performance of different feed-water heaters or condensers, it is customary to use the over-all coefficient of heat transfer. A much better analysis or prediction of performance under new conditions can be made by using the total thermal resistance, according to W. H. McAdams, T. K. Sherwood and R. L. Turner, in their joint paper on heat transmission from condensing steam to water in surface condensers and feed-water heaters.

The total thermal resistance, they pointed out is the sum of the separate resistances; that on the vapor side, that of the tubes, that of any scale or deposit on either surface and that of the water side. Each of these resistances is the reciprocal of the corresponding heat transfer coefficient in B.t.u. per hour, per degree of temperature difference, per square foot of condensing surface.

The numerical application of this method is of so much practical interest that an abstract covering all the essential points of the method will be published later.

Discussion

In discussing this paper, J. M. Taggert questioned whether, with a water velocity of one foot per second, there was turbulent flow present. He also stated that a study of the resistance of the vapor side, r_v, was desirable, as it probably varies with the air film and the direction of steam flow.

Theodore Baumeister, Jr., agreed with the authors that the thermal resistance was the correct method of attack rather than the over-all coefficient, and he hoped this work would soon be extended to take care of the case of condensing high-pressure steam.

G. L. Kothny, like Mr. Taggert, thought that more work should be done on the question of non-condensable gases and on vapor velocity.

D. K. Dean suggested that the first power of the velocity in the water resistance term might work as well as 0.8 and there would be a resulting simplification.

In answer to these various men Professor McAdams stated that, while completely turbulent flow would require infinite velocity, the critical velocity at which turbulence starts with water flow is only about one-eighth of a foot per second. So the flow is certainly turbulent with the lowest velocity considered, one foot per second. The question of the resistance of the steam side is now being investigated. However, any results found will not change the analysis very much because the water resistance is of so much greater magnitude. Other exponents have been tried, but the value 0.8 works well and has been experimentally proved. It is true, with the usual low water velocities, increasing this to 1.0 would have little effect.

Smoke and Public Health

ALL the papers and discussion at the Tuesday morning session on smoke abatement stressed the point that the bearing of smoke on public health is perhaps the most important aspect of the damage done by smoke, and that it is the element appealing most strongly to public enthusiasm.

Experience in Pittsburgh

H. B. Meller

A PAPER by H. B. Meller, Chief of the Bureau of Smoke Regulation of the City of Pittsburgh, Pa., on Smoke Abatement, its Effects and its Limitations, was read by the secretary in the absence of Mr. Meller. The author's purpose was to show that smoke abatement, as it has been carried on in a number of cities, has been of material benefit to manufacturers and to the public. He also desired to point out that anti-smoke laws have been framed for the purpose of eliminating only a part of the air-pollution evil, and that part the less grave and the less menacing to health. Attempts to enforce existing anti-smoke laws, he said, are more or less abortive, because of the false ideas of economy in providing only a fraction of the force necessary.

In describing methods used to minimize smoke, Mr. Meller used Pittsburgh as an example because of his long experience in that city.

A weakness, he says, has been that the comparatively few persons engaged actively in smoke abatement, have been constrained to follow the lead of the manufacturers rather than to set a high standard which the manufacturers would be given a reasonable time to meet.

The exemption of residences and apartment houses seemed necessary in the past but Mr. Meller believes that it should now be repealed. It exempts approximately 100,000 chimneys in the City of Pittsburgh. The requirement that designs for new furnaces or for alterations be submitted for approval has obviated much trouble.

Mr. Meller says that for nearly four years it has been possible to procure the necessary co-operation of users without resorting to suit. Compliance through co-operation is more valuable to the city than when forced.

It is axiomatic, he says, that in any community the efforts should be to regulate plants so that the natural fuel for that district, which will be the cheapest, be used without violation.

Pointing out the importance of having a chimney of sufficient height and cross-sections, he remarks that the formulas commonly used for chimneys for power and mill plants, do not apply to low-pressure heating plants, especially the smaller ones, where long firing periods are desirable and widely used. Little is known concerning the draft drops through such boilers or the size of chimney required. Attempts are being made to secure this information, through tests where necessary, and it is hoped that the data can be published in the near future.

Mr. Meller emphasized the importance of providing ample combustion volume and presented tables showing the minimum and preferred setting heights for various types of boilers with several different types of stokers.

With gas or oil, or coal fed by mechanical stokers, the regulation of secondary air is simple. With bituminous fuel, hand fired, it is not. Considerable care is necessary to make certain that the proper secondary air is introduced in this case.

In correcting conditions in manufacturing plants, plant owners and operating officials co-operate to the fullest extent and large sums have been spent in changes to improve combustion. In work of this sort, each furnace is treated as a separate problem to be solved by the owner and the city officials in co-operation.

Railroads, too, have made remarkable improvements as regards smoke. The restrictions are somewhat closer than on stationary plants, and the railroads maintain twenty inspectors who co-operate with the city officials. Mr. Meller contrasted this with the force of four inspectors employed by the city to cover all plants within the corporate limits.

In addition to constant observation by their inspectors, the railroads have taken steps to improve their equipment by the installation of arches in the locomotive furnaces, the removal of combustion tubes, and the use of low-volatile coal in yard locomotives. The routine of lighting fires has been carefully worked out to avoid smoke. An important factor has been the education and co-operation of the engine and house crews. The saving has been such that there is no question about the continued co-operation of the railroad officials.

Mr. Meller said that perhaps the greatest needs just now are for a uniform method of rating boilers in terms of output, fuel consumption and draft requirements, so that chimneys may be properly proportioned; for the elimination of the exemption of any class of buildings or plants from regulation under the ordinance, and for the development of a smokeless fuel at a reasonable price for domestic use.

Records of the Bureau of Smoke Regulation of the City of Pittsburgh, in 1923, indicated that as compared with 1914, approximately 80 per cent of the dense smoke prohibited by ordinance, had been eliminated.

Pending the development of a dust precipitator available at low cost, said Mr. Meller, more attention might properly be given to the use of low ash fuels.

Comparison of surveys made in 1914 and in 1924, however, shows a marked decrease in dense smoke with a material increase in solid matter deposited. The increase may be due in part to the growth of the city and the displacement of gas as a furnace fuel.

In summary and conclusion Mr. Meller said that ordinances for the elimination of dense smoke are well worth while. It is possible to enforce fair regulations without undue hardship upon the manufacturer, and in a large majority of cases compliance has resulted in a material saving of fuel. Better results could be secured if cities could employ larger forces of inspectors.

Much has been done in educating plant owners and equipment manufacturers to make changes that will admit of operation within the law. It must be considered, however, that the problem is one of evolution, not revolution.

Discussion of the Meller Paper

Among others who discussed Mr. Meller's paper, A. A. Bato remarked that much depends upon the skill and training of the fireman, and yet that nothing is done to force him to learn proper methods. He outlined the Prussian system of state-operated schools and licenses.

H. W. Clark[1] remarked that a liberal ordinance so facilitates enforcement and encourages co-operation that it more than offsets the additional smoke permitted under a strict interpretation. Prosecution is to be avoided, especially of householders, whose need is above all for education.

John Barkley, of the United States Bureau of Mines, called attention to the fact that the statement that half the air must be supplied above the fire applies only to an ideal fuel bed. Sufficient air usually enters through holes in the fire and around the edges.

John Hunter testified to the effectiveness of introducing hot air over the fire, and to the importance of helping the public to solve the problem rather than punishing them for failing to do what they do not know how to attempt.

[1] Chief Smoke Inspector, Salt Lake City.

The Physician's Testimony

Dr. W. C. White, pathologist of the United States Public Health Service, and chairman of the Medical Research Committee of the National Tuberculosis Association, read a paper entitled "What is Known About the Effects of Smoke on Health." In the last fifty years, said Doctor White, our cities of greatest industrial activities in steel and railroads, have turned day into night and night into intense darkness. There are many reasons for demanding the control of smoke, but we have so far failed to make the most powerful of all reasons—injury to health—so convincing that all will clamor for its suppression.

After outlining the history of the investigations of the physiological effect of smoke, Doctor White outlined the results of a study undertaken in 1914 in the City of Pittsburgh, which he said is an ideal place to pursue such study, owing to its large differences in elevation and its smoke production.

Pittsburgh presents two startling facts. It has a low tuberculosis death rate year after year. On the other hand, it has the highest pneumonia death rate of any community in the world. Analysis of the pneumonia death rate of the city by wards made it clear that the denser the smoke content of the air, the higher is the pneumonia death rate. On the contrary, the density of smoke seems to bear no relation to the tuberculosis death rate. It is probably safe to say that smoke has no influence on tuberculosis, but a tremendous influence on acute lung diseases. If it can be definitely proved, as the aforementioned study indicates, that smoke causes a high death rate from pneumonia, this will be a powerful argument for smoke abatement.

Doctor White reasoned that if acute diseases of the upper air passages are more prevalent in a smoky atmosphere, one would expect to find the number and wealth of physicians devoting themselves exclusively to the treatment of such diseases to be greater in Pittsburgh than in cities free from smoke. He found that the register of American physicians indicates 41 nose and throat specialists for a population of 580,000 in Pittsburgh, and 40 in Baltimore for a population of 730,000. This may indicate a great added expense to the citizens of Pittsburgh.

Doctor White made a detailed study of eight city squares in one of the low river level wards of Pittsburgh. The outstanding observation in this district was the prevalence of acute respiratory diseases.

Such limited evidence is indicative, but not conclusive, said Doctor White. As yet we have nothing sufficiently convincing. He therefore suggests as a practical test, that properly correlated agencies join with the City of Pittsburgh in a co-operative plan of research to determine definitely the effect of smoke upon health.

He then discusses the manner in which carbon particles in smoke are carried through the body and lodge

in the respiratory tract, whence they are carried throughout the body, producing abnormal conditions conducive to bacterial infection.

All discussion of the antiseptic properties of smoke seem to Doctor White futile, for there is not the slightest evidence of its activity in this way within the animal body, although it has been shown that soot, either by physical or chemical attributes, is germicidal for certain organs in test tubes. The supposition that carbon increases the incidence of cancer is probably unfounded. The cancer death rate for cities in the United States is highest in San Francisco, one of the choice climates of the world. Pittsburgh, smoky in the extreme, on the contrary has a comparatively low death rate from cancer.

Carbon Emitted from Smokestacks

The dusts associated with carbon emitted from smokestacks probably are of a great deal more importance than carbon. Of them we know practically nothing, carbon as a visible suspension so overshadows every other particle. Yet, in a day when catalysts are a dominant factor in chemical activity, it is conceivable that small traces of other substances may be of great importance. Of one dust, silica, we know a great deal. Long exposure to it stands alone as the one proved baneful influence from dust to which man is exposed. It not only is capable of destroying him and other animals through a series of definite pathological changes, but it is the one substance which we know favors the tubercular process. It does this possibly by some chemical process inaugurated by minute amounts over a long period of exposure. It seems almost certain that carbon unaccompanied by siliceous dust is not a permanent deposit in the lungs, for it is easily expelled without the chemical co-operation of silica-dust particles.

Effects of Other Substances

We can demonstrate the influence of minute doses of manganese, iron, arsenic and other substances on plant, animal and microscopic life. It would seem therefore, said Doctor White, that similar influences occur by exposure over long periods to minute amounts of the same substances used in industrial processes and passed on to the air we breathe. All these substances can reach our internal chemical human machinery by transport in the bodies of monocytes, which are wandering cells traveling about the body, or by direct absorption in solution, and they may readily be responsible for both physical changes and emotional waves in our population. However, we know practically nothing of this subject at this time.

Doctor White closed with a plea for carefully planned study, with Pittsburgh as an experiment center, to gain for us the knowledge we lack today. When we have obtained this knowledge, he said, we shall be able to speak with authority, not only about the pollution of the air with carbon, but also about all the dust which may now or in the future pollute the air we breathe.

Dr. Jerome Meyers, a New York physician, discussed the effect of smoke on the incidence of cancer, and voiced the belief that, while smoke is probably not the whole cause, it seems to be an important item in the spread of cancer, perhaps through the action of traces of certain chemical substances in the products of combustion.

The Human Element

Osborn Monnett

In the absence of Osborn Monnett, consulting engineer, of Chicago, Ill., the secretary read his paper on the "Present Status of the Smoke Problem." The real problem today, he said, is the small heating plant. Little work has as yet been done in the way of improving such plants and in few cases are there any regulations governing their installation. Even ordinary precautions are practically neglected. Efforts with this class of plant have been confined to using improved methods of firing. It is thereby possible to decrease the smoke density 75 per cent and increase the efficiency 15 or 20 per cent by the decrease in the deposit of soot on heating surfaces. Small heating plants are responsible for about 25 per cent of the total smoke in the heating season and should receive a proportionate amount of attention.

In Memphis, during a recent survey, a squad of high-school boys, without previous experience, made an average reduction of 60 per cent in smoke density in a group of homes with a varied assortment of equipment. In other residence localities where educational methods have been tried using student instructors calling on householders, the smoke has been reduced 50 per cent.

Taking the smoke problem as a whole, we have at least a theoretical solution for many problems confronting us, yet with all this engineering development, the smoke is still with us and in most instances it is getting worse instead of better. It is evident, Mr. Monnett said, that there is more to the problem than well worked out engineering designs.

There is the human element. It is not feasible to *make* anyone do anything. More smoke is stopped by diplomacy than by ordinance, and more frequently than not its abatement results incidentally from a general overhauling and modernization of the plant to carry the load.

There is need for instruction for better equipment and for supervision. Adequate smoke abatement is going to cost more than has been realized. None of the cities in the soft coal district has ever had sufficient appropriation really to cover the field. From experience and observation in various campaigns in various parts of the country it can be stated that a total expenditure of $50,000 per year per million of population is about the lowest estimate that will enable all phases of the subject to be handled with any degree of satisfaction. This constitutes an insurance rate of 0.3 per cent on the fuel loss and damage per capita to the community. This is not a high rate, although far in excess of the sum set by most cities in this work.

Recent developments, said Mr. Monnett, emphasize the importance of supervision. After everyone has been instructed and the necessary improvements in equipment have been made, it is imperative that a constant watch be maintained and a follow-up system installed, as otherwise the efforts are wasted. Firemen simply will not take the care required in the operation of their furnaces unless they know they are being watched. Looking into the future, Mr. Monnett thought

it not unreasonable to expect that prepared fuel will play an important part.

Mr. Monnett remarked that one of the best features of our carbonized fuel is that it will automatically solve the part of our smoke problem that is most difficult of control—the human element. Providing a foolproof fuel that could be shoveled helter skelter into any kind of a fire pot, without any precaution, would remove the last barrier to the realization of our dream of smokeless cities.

None of these things is going to come over night. At the proper time, depending on economic conditions, the fuel interests and technologists will meet the situation. In the meantime we should not relax our efforts along present lines, as it is by these efforts that the field will be prepared for more radical measures.

Discussion of Monnett Paper

H. W. Clark discussed the losses incident to smoky combustion, and remarked that these usually force the larger plants to stop smoking, but that they influence the small user hardly at all, since he does not know what his losses are. He cited data showing what may be accomplished in the way of savings, by proper methods used in smoke prevention.

Prof. A. G. Christie suggested that smaller plant owners might club together for the employment of a skilled combustion engineer to supervise the boiler rooms of the entire group.

V. J. Azbe told of the work done by the St. Louis Section, and showed a design of household warm-air furnace worked out by the section and presented to the local furnace manufacturers, who plan soon to market the new type of furnace.

The local sections of Cleveland and Detroit, represented by McRae Parker and Morgan B. Smith, reported effective work in helping the city governments in the solution of the smoke problem. Mr. Smith mentioned the need for more precise methods of measuring smoke density.

General Session Papers

A novel and important feature of the General Session on Tuesday afternoon was a demonstration of a new type of compressor operating without valves, glands or clearance. Other papers dealt with the measurement of static pressure of flowing air, emergency stops of elevators and waste lubricated bearings. The last-named paper being in the railway field, is not covered in the following abstracts.

Measurement of Static Pressure

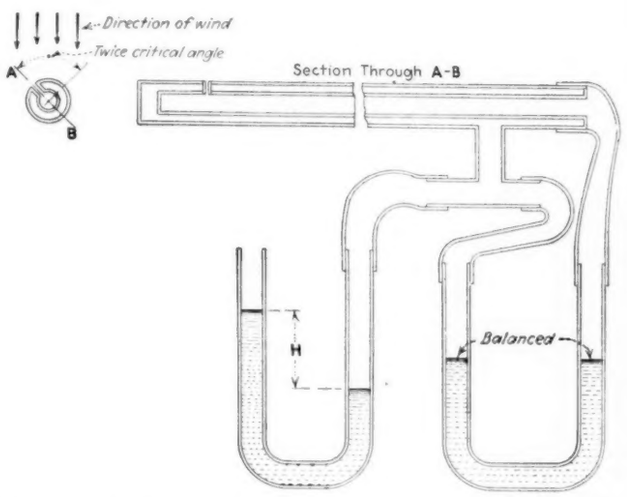
The method of measuring static pressure in air flow, given by C. J. Fechheimer, is of interest both because of the ease with which the instrument can be introduced into the region of flow and because of the accuracy resulting.

If a tube with a hole in its side wall is introduced into stream flow in such a manner that the hole points directly into the stream, the reading on a manometer connected with this tube will be closely the static *plus* the velocity head. On the other hand, if this tube is revolved 180 deg. so that the orifice points downstream, the reading will be somewhat more than the static *minus* the velocity head. This suggests that if the tube is placed in just the proper intermediate position, the static head alone will be indicated on the manometer.

Experiments by Dr. H. L. Dryden, of the Bureau of Standards, and also the author show that the angle between the direction of the stream and the position where the influence of the velocity head is zero, is a little less than 40 deg. This angle is called the critical angle.

In the manometer connection devised by Mr. Fechheimer and shown in the accompanying illustration, the critical angle was taken as 39.25 degrees.

The device, as built, consists of two small tubes, the diameter of the outer one being ¼ in. and the inner ⅛ in., the smaller one going into the outer. The inner tube hole, and the annular space between the two tubes communicates with the outer surface by means of another small hole displaced from the first hole circumferentially by double the critical angle. The inner and outer tubes are then connected independently to the two sides of a U-shaped tube or other manometer, and when the device is in a moving stream, it is turned on its axis until the U-tube reads zero. Then the stream bisects the double-angle, so that if one side of the U-tube is then opened to the atmosphere, the static pressure only will be read. There is, of course, the possibility that the tube be turned 180 deg. from the impact side, and then the reading would be too low. To overcome this difficulty, it has been found advisable to use two manometers, one for balancing and one for reading the static pressure, a suitable T-connection being used on one side for connecting to the second manometer. Then the manometer used for balancing would read zero for the two positions of the pressure tube, which are 180 deg. apart. The second manometer, which reads the static pressure, would then record a high and a low value for the two balanced positions. The high value is the correct static pressure. If the pressures are below atmosphere, the high reading is the one that is numerically smaller.



Manometer connections for measuring static pressure

One of the obvious advantages of this instrument is that the tube that must be inserted in the flow is only ⅛ in. in diameter, which means that it can be easily introduced. A second advantage is that, although it may not give a correct indication with turbulent flow, the double form of manometer gives a better chance of locating the orifice in the most favorable position.

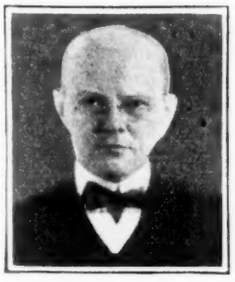
Discussion

Following Mr. Fechheimer's paper several discussions were read. According to H. L. Dryden, of the United States Bureau of Standards, the errors of the method shown should never exceed 10 per cent and would generally be much less. Regarding the proper angle between the two holes, he said that this would vary with the size of the cylinders and their distance from the end of the cylinder. The correct angle is larger for holes in the center of a cylinder running all the way across the wind tunnel and decreases as the diameter of the cylinder is increased. He also called attention to the effect of the size of the cylinder on the flow of air in the duct.

Frank W. Caldwell, an aëronautical engineer of Dayton, Ohio, asserted that instruments of this type should be calibrated in a wind tunnel. Another aëronautical engineer suggested adding a third hole for the measurement of impact pressure. Instruments of this type, he pointed out, could be used to determine the precise direction of flow, by turning the tube until a maximum reading of the impact orifice was obtained.

J. M. Spitzglass, of the Republic Flow Meters Co., recommended the addition of a sharp-edged impact tube which could be separately adjusted to give the total pressure (static plus velocity) correctly. S. A. Moss, of the General Electric Co., said that his laboratory had checked the author's results by actual experiments.

Emergency Stops for Gearless Traction Elevators



F. Hymans

F. HYMANS of the Otis Elevator Company, in a paper "The Emergency Stops of the Gearless Traction Elevator at the Terminal Landings," discussed the performance and limitations of the emergency terminal stopping devices, and gave the calculations necessary to determine the required overhead clearances. The discussion has been confined to an investigation of the oil buffer and the limit switch. The theory of the oil buffer is given as developed by the author; which considers the properties of the buffer if struck by a free weight at a given speed. It is shown that this theory applies when a buffer is suitable for service with an elevator. On the other hand, a satisfactory buffer when engaged as a free weight, may be wholly objectionable if the same weight instead of being free is the car or counterweight of an elevator.

An investigation made, showed that the limit switch alone at the terminal landing is inadequate as an emergency terminal stopping device unless the top and bottom clearances are exorbitant. The results of an investigation of the stopping of an elevator, when brought about by the action of the buffer alone, showed that an intimate relation exists between the buffer and the particular elevator it is to serve. It is shown that a well-designed buffer is always an excellent terminal stopping device for the descending member of the elevator, but not in general for the ascending member, unless the buffer stroke and the top clearance are considerable.

It is brought out that the accepted notion, that the oil buffer and the limit switch are two independent emergency terminal stopping devices, capable of bringing the elevator to a safe stop within the usual clearances, will have to be abandoned, as the operation of the two should be co-ordinated to insure satisfactory emergency stopping with a minimum clearance.

A factor not generally appreciated, is that the emergency stops of the gearless traction elevator, when they occur at high speeds, are nearly always associated with slack hoist ropes and followed by a fall of the ascending member through a corresponding distance. When this slack is taken out of the ropes, very heavy stresses are set up in the ropes and machine. This, in the author's opinion, is the reason for the necessity of re-aligning the machine after a field test or for finding the shaft of a machine fractured. This is also considered as an argument for dispensing with field tests that needlessly develop a considerable amount of slack in the hoisting cables. It is shown that as moderate amount of slack as is two feet for ropes 400 ft. long will cause considerable stresses even if the falling member is the empty car.

New Valveless Compressor Based on Ancient Invention

OVER two thousand years ago Archimedes of Syracuse invented a helical screw pump to remove the water from the hold of a large ship built by King Hiero II. Since that time it has been used for pumping, chiefly in primitive communities.

A modern development of this device into a gas compressor without pistons, glands or internal lubrication was described in a paper by J. G. DeRemer, consulting engineer for the Savage Arms Corporation. While the immediate application is to household refrigerating machines, the possibilities of extension to larger compressors made this paper of general interest to power-plant engineers.

If a tube is coiled into a helix or corkscrew and rotated about the inclined axis of the helix, with the lower end of the tube dipping into some liquid at each rotation, slugs of liquid and air will be carried up the tube. If, now, the upper end of such a tube is rigidly connected with a rotatable tank or receiver, both the air and liquid will accumulate in the receiver, with a resulting increase in pressure there. Provision can be made for returning the liquid to its original position, so that the air alone will remain in the receiver, where, if operation is continued, it will accumulate pressure limited only by the ability of successive liquid plungers to force more air up the tube.

Even when mercury is used as the liquid, the pressure limit of an apparatus in this elementary form would be altogether too low for use as a refrigerating compressor. The apparatus described by Mr. DeRemer gets around this difficulty by using centrifugal force instead of gravity, the helix being attached rigidly at an angle to a vertical axis about which it revolves as a

conical pendulum at considerable speed. The top is mounted on a universal joint, making possible the use of flexible tubes for the incoming and outgoing gas connections.

The commercial compressor is made entirely of seamless steel tubing, gas welded. It is surrounded by a finned aluminum radiator and mounted in a cast-iron frame revolved at from 360 to 440 r.p.m. by a quarter-horsepower motor operating through a friction drive.

Mr. DeRemer also described a horizontal rigid-element type of refrigerating machine in which both expansion coil and mercury compressor are mounted rigidly on a single shaft, eliminating all gas connections to moving parts. Although rigidly connected, the two elements revolve in chambers separated by an insulating wall. In one compartment water sprays over the condenser coils wrapped around the revolving compressor and in the other brine is sprayed over the revolving expansion coil. The whole fluid system is sealed tight and will retain its charge indefinitely.

Mr. DeRemer's paper brought out much favorable comment. ELMER A. SPERRY, after congratulating the author on the ingenuity of his device, recommended caution in applying it to the compression of air. Experiments made with mercury floats for gyroscopes had shown, he said, that air would form a scum over the mercury. This comment did not, of course, apply to a sealed system using gas or vapor not reacting with mercury, such as the fluids commonly used in refrigerating systems.

A. R. STEVENSON, JR., of the General Electric Co., mentioned other devices that had been employed to avoid the use of glands and leakage. One method is to inclose the driving motor in a sealed chamber with the compressor. A device widely used in Europe drives an induction-motor rotor in a sealed chamber by means of a stator surrounding the chamber. He thought Mr. DeRemer's solution of the lubrication problem very attractive, but wondered if the flowing back of mercury might not cause vibration.

Future of Low-Temperature Carbonization Still in Doubt

IN RECOGNITION of the great present interest in coal carbonization and gasification among mechanical as well as chemical engineers, the fuels session on Wednesday morning was devoted to the subject of coal processing. W. H. Blauvelt, consulting engineer, discussed the distillation of coal in a general way without description of specific methods or apparatus. Papers by A. C. Fieldner, chief chemist United States Bureau of Mines, and R. S. McBride, consulting chemical engineer, dealt respectively with low-temperature carbonization and complete gasification.

* * *

Distillation of Coal

THE distinction between low- and high-temperature carbonization was made clear by Mr. Blauvelt.

In low-temperature carbonization, he pointed out, the temperature must not exceed 1,400 deg. F., at the most, if loss by destructive distillation is to be avoided. The difficulty of producing the necessary high output at these low temperatures has been one of the chief hindrances to development in this field.

To show the difference in quantity and composition of the gas produced by the two processes, the following table was presented:

	High-Temperature	Low-Temperature
Cu.ft. gas per net ton of coal	11,000–13,000	4000–5500
B.t.u. per cu.ft.	525–600	675–800
Analyses:	Per Cent	
Hydrogen	50.0	27.5
Methane	33.0	48.0
Illuminants	3.0	10.0
Unsaturated hydrocarbons	....	3.1
Carbon monoxide	5.5	7.3
Carbon dioxide	1.5	2.5
Nitrogen and oxygen	7.0	1.6
	100.0	100.0

The tars, Mr. Blauvelt said, are also quite different in composition. Low-temperature tars are more limpid, contain much less pitch and are similar to crude petroleum with the addition of tar acids, chiefly creosols. The higher gas yield of the high-temperature process is obtained at the expense of gas-heating value and yield of valuable oils. The high-temperature process, however, gives a much greater yield of ammonia.

* * *

Low-Temperature Carbonization

A. C. Fieldner

THE paper of Doctor Fieldner was too long to be covered with any degree of completeness here, but a few points of special interest may be brought out. If coal is carbonized in externally heated retorts, he explained, the wall temperature can be only about 1,100 deg. F. for low-temperature as against 2,200 deg. F. for high-temperature carbonization. This has a notable effect commercially by cutting down to four or five inches the thickness that can be carbonized in a reasonable time in a single-stage static process. Hence, it becomes necessary to use many small-diameter retorts or to speed up the rate of carbonization either by spreading the coal in a thin layer on the heated surface or by agitating the coal (bringing fresh portions continuously in contact with the heated walls) or by passing large quantities of hot producer gas, products of combustion or superheated steam through the mass of broken coal.

Doctor Fieldner stated that the Illinois district was probably the most attractive from the viewpoint of smokeless fuel production. Most of this coal is high in moisture and is not suitable for metallurgical coke. The mines have a large surplus of fines which it is difficult to sell at any price.

The Old Ben Coal Corporation, recognizing the pos-

sibilities of beneficiating this low-grade coal, has developed the Greene-Laucks process. In this the coal is propelled upward by a screw conveyor in an annular retort heated on the outside and also within the hollow conveyor shaft. The action of the slowly revolving screw agglomerates the plastic screenings into marketable sizes of lump coke. The maximum temperature is 930 deg. F. The Old Ben Coal Corporation is now erecting a large experimental retort operating on the same principle, but nine feet in diameter, at its mines in Franklin County, Illinois.

Professor Parr, of the University of Illinois, has also developed a process for producing domestic smokeless fuel from mid-continent coals. The heating is accomplished successively in two retorts, one of which is rotating.

Probably the most highly developed low-temperature process today using a full-size commercial-scale retort is that of the Consolidation Coal Products Company, according to Doctor Fieldner. This retort is a modification of the primary carbonization retort of the Smith or "Carbocoal" process installed at Clinchfield, Va. The original Carbocoal retort was not practical because of breakage of the stirrer arms through resistance of the pasty, fused mass of coking coal, as well as other difficulties.

The McIntire retort has solved this problem and has successfully carbonized coal from the Pittsburgh bed—a coking coal—for considerable periods (two to six months' continuous operation) at the rate of 50 tons a day. The semi-coke produced is partly lumps and partly granular. It is not suitable for domestic fuel without subsequent briquetting and recarbonizing. However, it could be pulverized for powdered-fuel furnaces.

With the coal heated to a maximum temperature of 842 deg. F., the following yields were obtained:

YIELDS FROM McINTYRE RETORT PER TON OF COAL CHARGED

Semi-coke (12-14 per cent volatile matter) per cent	75
Gas (875 B.t.u. per cu.ft.), cu.ft.	3000
Crude tar oils (1.080 sp.gr.), gal.	30
Ammonium sulphate, lb.	10

The precarbonization of coal for byproduct recovery in conjunction with stoker-fired boiler furnaces of power plants has been the subject of extended experimentation by Merz and McLellan in England and by the Julius Pintsch Company in Germany. The processes are similar; the carbonizing retort is placed directly in front of the boiler furnace and the semi-coke is discharged on the chain-grate stoker. The coal is carbonized by circulating hot flue gases from the boiler furnace, either alone or with superheated steam in addition, through the descending coal. The coal used must be non-coking and free from excessive amounts of fines. Coking coals melt together and prevent even distribution of the heating gases. Fine coal is carried over in the gas current and deposits dust in the tar.

Since the time of carbonizing a lump of coal by hot gases decreases with the size of the lump, it follows that pulverized coal introduced into a stream of hot gases should be carbonized very rapidly. The McEwen-Runge process of the International Combustion Engineering Corporation is based on this principle. A 210-ton-per-day experimental unit has been built at the Lakeside Plant of the Milwaukee Electric Railway & Power Company. The process aims to recover byproducts from pulverized coal by an internal heating method such that the carbonized residue can be used directly as pulverized fuel without repulverizing. The heating is so designed that the primary gaseous products can be recovered with minimum dilution by inert heating gases, and they are said to be rich enough for distribution as town gas.

The process is two-stage. It is carried out in two vertical cylindrical retorts, the first stage being superimposed on the second. The function of the first stage is drying and removal of some water of constitution along with CO_2. The heating is countercurrent; hot combustion gases (700 deg. F.) and air containing heat recovered from the carbonized residue are passed in at the base of the first retort, where they meet a descending stream of pulverized coal, giving up their heat to it. On passing through the retort these gases contain but little combustible and are rejected.

The hot coal falls into a bin from which it is fed mechanically into the second-stage retort. The descending coal is carbonized by (*a*) preheated distillation gases; (*b*) products of combustion introduced into the tower, or (*c*) products of combustion generated within the retort by the admission of a suitable quantity of hot air. The maximum temperature here is 1,500 deg. F.

Auxiliary apparatus includes the usual coolers and scrubbers for removal of the tar from the gas. The process is continuous—requiring six minutes for both stages. The process goes to the ultimate extreme in rapid heat transfer to the coal and has possibilities of very high throughput in relatively low-cost equipment. But the mechanical difficulties to be solved seem very great, especially in separating the fine dust from the vapors.

The pulverized-fuel-burning people, said Doctor Fieldner, evidently have faith in the pretreatment of pulverized coal and the recovery of byproducts in connection with central power generation.

No single method so far tried has, in his opinion, met with unqualified technical success, although a number have shown promise. The processes that depend on initial heating by combustion gases are simpler and require less capital expenditure per ton of coal carbonized, but they are limited to non-coking, weakly coking or briquetted coals; also the gas is of low calorific value and the light oils are not recoverable from the diluted gas. However, such processes are promising for future developments in combination with large central-station power plants or industries using large quantities of gas of low heating value, at such future time as diminishing petroleum supplies creates a demand for low-temperature fuel oils.

Complete Gasification of Bituminous Coal

THE greatest advance in industrial fuel utilization in the United States will probably come through complete gasification of bituminous coal, according to a statement made by R. S. McBride in his paper on complete gasification. He used the expression in its broader sense to include any process or combination of processes which converts substantially all of the bituminous coal used into fuel gas without manufacturing coke as an end product. In this sense the gas producer and the water-gas machine, when using bitu-

minous coal, are complete gasification devices. Moreover, the combination of any coal-gas or coke-oven unit with a water-gas machine, or gas producer using coke, affords complete gasification. The biggest field for the gas produced by such processes is domestic and industrial heating, in the author's opinion.

The yardstick for measuring the value of a gas is the cost per million B.t.u. at the consumers plant. Of course gas should not be compared with a solid fuel on this basis. Ordinary producer gas would be ideal for most industrial uses were it not for the low heating value which enormously increases the cost of distributing a million B.t.u. Of the various processes of complete gasification Mr. McBride felt that perhaps the direct use of bituminous coal in water-gas machines held the greatest promise.

Coal Processing Discussion

The discussion was notable for a divergence in opinion on several important points. J. A. Perry, of the United Gas Improvement Co., expressed pessimism as to the future of low-temperature carbonization. The process, he said, could not be considered except with low-grade and slack coals, on which the gas companies would not consider paying freight. He doubted if more than four cents per gallon could be obtained for the crude tar produced. From the point of the gas manufacturer Mr. Perry attached more importance to the saving of gas oil and of water-gas coke, than to the greater tar yield of the low-temperature process.

Prof. A. G. Christie, of Johns Hopkins University, stated his belief that low-temperature carbonization could have only a limited field for many years to come, basing this opinion upon the belief that the liquid by-products must remain of secondary value in the United States until petroleum resources have been exhausted. He did not see any immediate prospect of such exhaustion, and pointed to the great supply of oil shale. Professor Christie was willing to concede a possible market for low-temperature char, as a domestic fuel in the anthracite consuming regions, but not at a higher price than anthracite.

George A. Orrok, consulting engineer, New York Edison Co., could see no advantage in selling tar to a distiller at five cents a gallon when it will bring seven cents as a fuel. Considering the fact that large boiler plants already average from 86 to 88 per cent efficiency on a yearly basis, he saw little opportunity for the economical use of low-temperature char in such plants.

Some differences of opinion developed over the commercial feasibility of distributing gas of low heat value, gas company representatives failing to agree with Mr. McBride that lowering of the heat value increased the cost of distributing a given amount of heat.

In his closure, Doctor Fieldner challenged Professor Christie on several points. He did not agree that the natural markets of low-temperature coke would be confined to the districts now using domestic anthracite.

Mr. Blauvelt in his closure stressed the point that no one was expecting to apply low-temperature carbonization commercially to high-grade fuels. The only hope of profit lies, he said, in using waste fuels costing from 25 to 50 cents per ton at the most. Moreover, the first cost of the apparatus must be as low as possible. Replying to Professor Christie on the matter of oil-shale distillation, he said that low-temperature distillation would be profitable long before the distillation of oil shale because the residue of shale distillation is worthless.

Oil Engines Receive Much Attention

THE papers presented by the Oil and Gas Power Division included studies of the thermodynamics of the internal-combustion cycle, a résumé of present-day developments and an exposition of a method of studying cylinder events by the shape of the indicator diagram.

The Modern Oil Engine

E. C. Magdeburger

THE present-day status of the Diesel engine with respect to constructional features was covered by Edward C. Magdeburger, Aide on Diesel Engines, Bureau of Engineering, U. S. Navy. The author's contacts being almost exclusively marine, the paper was devoted almost entirely to a discussion of marine engines, to the unfortunate exclusion of many designs of stationary engines.

Oil engines of the four-stroke-cycle type, being historically the first to be developed commercially, have attained a high degree of reliability and show only minor variations in the design of the vital parts, as the author stated.

One of the greatest hopes for development of the four-stroke-cycle engine lies in the adoption of higher shaft and piston speeds.

The Burmeister & Wain Company built its double-acting experimental cylinder to run at high speeds, and details have been incorporated in a number of large engines in apparently successful operation on the high seas. The high piston speed of this engine, 1,238 ft. per min., is a considerable advance over the prevailing practice of the same builder and contributed considerably to the reduction in weight shown as compared with single-acting engines built by its American licensee.

Another type of trouble that had to be conquered was the increased heat stresses resulting from increase in engine speed. These are confined mostly to piston crown and cylinder head, and with the existence of the two idle strokes of the four-stroke cycle do not reach excessive limits and become of importance only after the cylinder bore exceeds 10 or 12 in. in diameter.

Besides the increase in speed, modifications in the orthodox crank mechanism have been studied, with the result that several solutions have passed the inevitable criticism following the attack of anything as established as was the single-acting four-stroke-cycle type.

A number of moderate-sized engines of the V-type have been built in Sweden by the Atlas Diesel Aktiebolaget and are offered by its American licensee, the McIntosh & Seymour Corporation, for installation in railroad cars. Such an arrangement undoubtedly produces a lighter and more compact engine.

A further step in this direction is the use of a com-

mon crank mechanism by two adjoining four-stroke-cycle cylinders alternately, as adapted to a large engine by the Hamburg-Mannheim Co., Ltd., the first engine of this type having been recently installed in a motorship.

Among the recent arrivals into the oil-engine industry is the application of the double-acting principle. As many as four different experimental cylinders of the four-stroke-cycle double-acting type have been built. Engines of two of these types have already been installed in substantial numbers for ship propulsion.

Whatever else extended service experience may prove or disprove, the results to date indicate conclusively that there is more than one way to design a successful four-stroke-cycle combustion chamber for the lower cylinder half, and the much discussed and feared stuffing box for the piston rod is no problem at all. Much credit is due to the Burmeister & Wain Company for their ingenious design of the piston rod that made it possible to design a combustion chamber using the standard Diesel cycle, and to the Werkspoor company for their more conservative and cautious solution of the lower cylinder problem, employing lower compression.

Probably the most natural step in weight reduction at first through would be the elimination of the injection-air compressor with its air coolers and considerable amount of high-pressure piping, including an air receiver or air bottle of considerable weight. The air injected with the fuel is really an ideal medium to separate the fuel charge into small particles and to accelerate and to carry these oil particles to all parts of the combustion chamber, exposing a tremendous surface of the fuel charge to the heat of the compressed-air charge in the cylinder.

Mechanical injection employing pump pressures ranging from 2,000 to 20,000 lb. per sq.in., has been adopted by numerous European builders as well as by a number of Pacific Coast builders and the Foos company in this country. The Beardmore Company used it in their high-speed engine that made the now famous cross-country run in a Canadian rail car. The low fuel consumption at all loads and the fine regulation even at no load are the outstanding advantages, in addition to weight reduction resulting from the elimination of air injection and the attached air compressor.

Any increase in shaft and piston speeds unfavorably affects the amount of combustion air that will find its way into the cylinder since velocities through the valves will also increase. In addition as the cylinder interior becomes hotter, the temperature of the incoming air increases and the amount decreases still further. Furthermore, normally not less than 7 per cent of the cylinder volume is filled with hot products of combustion from the preceding cycle that cannot be displaced by the upward moving piston. The recovery of this loss was the subject of experiments by the Falk Corporation. The inlet valves for this purpose were connected to a closed manifold, where a pressure of about 15 lb. abs. was maintained by a blower. The statement has been made that such scavenging of clearance volume permits of a 38 per cent increase in power as compared with unscavenged operation.

Methods of scavenging of two-stroke-cycle engines may be divided into two groups—those where scavenging air charges the cylinder without changing its direction of flow and those where it reverses or otherwise changes its direction of flow.

The largest stationary engines built in this country, the Nordberg 3,750-hp. units, are of the first type. Here the solution appears to have been found in the use of a two-piece cylinder head. The inner one, exposed to the heat of the combustion, is made of cast steel, as simple as possible and free to expand, whereas the cylinder head bolts pass through the heavy outer head made of cast iron and serving as part of scavenging receiver. Another successful solution is that by the Krupps, who introduced a separate water-cooled shield to protect the heat-exposed surface of the cylinder head.

Opposed pistons inherited from gas-engine practice have been used by Junkers and Fullagar, each of the pistons controlling one set of ports. The sliding cylinder, the stroke of which is only sufficient to uncover the upper or scavenging ports, has been incorporated by Maclagan in the design of North British type of oil engine.

The possibility of dispensing with all valves is a valuable feature of a two-stroke-cycle engine. Simplicity of such arrangement, while valuable in small oil engines, where it is often paid for by substantial rise in fuel consumption and higher specific weight, becomes particularly important in large engines, where the valves and valve gear and its drive become important problems of design and maintenance. Hence, efforts to improve the scavenging obtained by the simple deflector of the scavenging air have been made, and this system is now used in such engines as Worthington, Neptune, Still and others.

A distinct type of scavenging was developed by Sulzer. Two sets of scavenging ports occupy about one-half of the cylinder periphery and have suitable guiding space so as to scavenge both the upper part of the cylinder immediately at the fuel valve and the space above the piston. The upper scavenging ports are opened by the piston before the exhaust and are therefore equipped with light automatic valves, whereas the lower are beyond the danger of admitting exhaust gases into the scavenging receiver and are piston-controlled only.

Thermodynamics Treated

ONE of the thermodynamic papers was entitled "A Temperature-Entropy Diagram for Air and the Diatomic Gas," the author being Harold A. Everett, Professor of Thermodynamics, Pennsylvania State College. Because of the added complexity that comes into the ordinary thermodynamic problems when the substance under consideration behaves as a vapor instead of a perfect gas, temperature-entropy diagrams have found much favor for the graphical solution of problems dealing with fluids that may undergo changes of state. For the so-called permanent gases, which are ordinarily encountered under conditions remote from their critical condition, the author stated that the various equations for perfect gases serve for most engineering problems and are so simple that temperature-entropy diagrams for them render small assistance and are seldom drawn.

However, there are cases frequently met in engineering practice where the assumptions underlying the development of the perfect-gas relations differ too widely from the actual conditions for their use to give satisfactory results. Most noticeably is this true in

cases involving high temperatures, as in internal-combustion engines, where very high temperatures may result from high compression ratios and from the combustion of the fuel.

For actual gases the specific heats increase with the temperature and differently for each gas. With gases of similar molecular structure, however, it becomes possible by dealing with one "mol" of the gas to formulate *one* equation for the specific heat that will hold for the several gases constituting that group. Using such an expression, it is possible to compute points for constructing lines of constant volume and constant pressure for this group of gases on co-ordinate axes of temperature and entropy. We have then a temperature-entropy diagram that takes cognizance of the variation of specific heat and permits a ready picturization of processes and cycles and the graphical solution of problems that would otherwise require the use of cumbersome mathematical expressions. Such a diagram makes it easy to predict final condition after adiabatic or isothermal change and the final temperature after the liberation of a known quantity of heat at constant pressure or volume.

The author, by making use of known equations on specific heat, etc., constructed two charts. One shows the relation of temperature to heat content, while the second is a temperature-entropy diagram.

R. C. H. Heck

TO PROMOTE the use of the ideal performance as a standard of comparison for internal-combustion engines, in a paper entitled "Ideal Gas - Engine Cycles," Robert C. H. Heck, professor of mechanical engineering, Rutgers University, presented a temperature-entropy diagram that can be used almost as readily as is the Mollier chart for the steam engine. The author developed a working chart that combines in one the temperature-entropy diagram and a diagram of internal energy and total heat against entropy, in which any horizontal line is a line of constant temperature, constant energy and constant total heat. He showed by trial upon representative examples, that this chart, based on the properties of an average gas mixture, gives essentially correct output for any working mixture within the range of gas-engine practice.

Avoiding the common type of chart, with its confusing multiplicity of curves, the plan employs the principle of moving curves, carried by templets. The chart carries one curve of constant-volume and one of constant-pressure heating, with horizontal scales of volume and pressure and vertical scales of energy and total heat or "enthalpy." These are so disposed that any problem can be solved by construction upon a separate working sheet, laid down across the chart, which will serve as a permanent record of the solution. A more complete outline of the paper together with the charts will appear in a future issue of *Power*.

PROFESSOR ELLENWOOD, Cornell University, was inclined to doubt the accuracy and feasibility of Professor Heck's thermodynamic chart. He claimed that the use of an average mixture was not acceptable and showed by a comparison of some of the values with results obtained with the use of real mixtures, that the chart gave inaccurate results. He insisted that each cylinder mixture should be covered by individual correct charts, if a comparison of actual engine performance with the ideal was to be made.

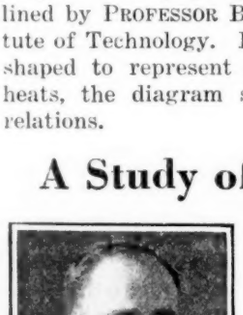
The ratio of the thermal efficiency of the actual and ideal engines, so he stated, is a true measure of the engine efficiency only in case both of these thermal efficiencies have been accurately determined, but a variation of 5 per cent in the ideal cycle efficiency may easily change the engine efficiency 10 or 11 per cent. Thus if an internal combustion engine has a thermal efficiency of 30 per cent, and the corresponding ideal cycle efficiency is 40 per cent, the engine efficiency is 75 per cent, but if the cycle efficiency is 35 per cent the engine efficiency becomes 85.7 instead of 75 per cent.

As evidence of how conveniently the ideal cycle efficiencies may be plotted, curves were shown for the Otto cycle.

In discussing Professor Heck's paper, PROFESSOR EVERETT pointed out that the ideal air cycle was adopted in 1905 by the Society of Civil Engineers, of England. In this it is assumed that the specific heat is constant, as is also the specific volume, and the fluid. In addition no heat is to be interchanged. He felt that this air cycle was the ideal and that if variation in mixture, etc., was to be considered, then Professor Heck's charts failed to meet all the requirements.

A novel method of obtaining temperature entropy diagram direct, by a pressure-volume indicator was outlined by PROFESSOR BERRY, of the Massachusetts Institute of Technology. By attaching proper shaped slides, shaped to represent logarithmic functions of specific heats, the diagram showed temperature and entropy relations.

A Study of Cylinder Events



P. H. Schweitzer

IN A paper entitled "The Tangent Method of Analyses of Indicator Diagrams of Internal-Combustion engines," P. H. Schweitzer, associate professor, Engineering Research, Pennsylvania State College, elaborated upon a discussion appearing in *Power*, April 10, 1923. After a dissertation on the significance of the instantaneous exponent of the expansion and compression curves of internal-combustion engines, the author outlines mathematically a method of ascertaining the exponent. The process involved requires the construction of the tangent to the desired curve point. This is done by first locating the normal to the point, followed by the construction of the tangent perpendicular to the normal.

The normal and tangent are found through the use of a silvered disk which reflects the image of the curve as an unbroken continuation of the curve when the plane of the mirror is normal to the curve. A scale fixed to the mirror permits the easy drawing of the tangent.

The paper was illustrated with numerous indicator diagrams upon which the theoretical and actual experimental curves were drawn. From these the author drew conclusions as to heat interchange, etc.

Session on Central Station Power

THE session on Thursday morning devoted to central-station power included three papers on steam-condenser practice and performance. Since the economy of a station depends on the maximum extension of the working range of steam expansion, the possibility of extending the lower boundary is just as important as that for the upper, and accordingly it is fitting that attention should be devoted to the possibilities of improving condenser practice.

The general recognition of the importance of the material presented was attested by the large attendance and the eager discussion that followed the authors' presentations.

The session opened with the annual report of the Power Division, presented by its chairman, H. B. Reynolds. He outlined developments in the power field during the past year in a comprehensive way.

Condenser Performance

IT IS difficult to abstract the papers on condenser performance, because the thirteen condensers for which data are presented, vary in so many particulars that it is impossible to draw general conclusions concerning the relative merits of any specific detail of design or construction. The intelligent condenser designer or operator, supplementing his own knowledge by a painstaking study of the comparative data presented in the three papers, should find them a very valuable contribution to the literature of power generation.

PAUL BANCEL, of the Ingersoll-Rand Company, read a paper on the "Operating Performance of Modern Surface Condensers," devoted largely to setting forth the results obtained with condensers of his design and the discussion of means whereby performance has been improved, and of the way in which these means operate to the desired end.

He exhibits the performance of a condenser by plotting a curve between the difference in temperature between steam and injection water, as ordinates, and the steam load in thousands of pounds per hour as abscissas. For a perfect condenser, this should be a straight line passing through the origin, and deviations from this position measure the shortcomings of the actual condenser.

It is apparent, said Mr. Bancel, that many tests and fragmentary readings on condensers are of little or no value. As with a boiler plant, the real test of condenser performance is continuous operation. Results of this kind are presented in the paper, and similar operating results should be used for comparison.

He then shows a log of one year's performance on a 9,000 sq.ft. condenser carrying loads as high as 168,000 lb. of steam per hour, and results from shorter periods of operation of a 25,000-sq.ft. condenser serving a 38,000-kw. turbine and of a 30,000-sq.ft. condenser serving a 35,000-kw. turbine that has been in service for several months.

The heat transfer coefficient, said Mr. Bancel, is a derived or secondary result and has its full significance only when embodied in a complete test report. Auxiliary services, such as steam to the air ejector jets and power to the water pump, must be given full consideration.

Mr. Bancel said that the principal features of design contributing to high efficiency and low air-pump power comprised shell shape, tube staging, external coolers, and longitudinal control of steam distribution. He explained and discussed these items in detail.

E. B. Ricketts

EDWIN B. RICKETTS, Research Engineer, New York Edison Company, and F. J. Chatel, Technical Engineer the Delray plant, Detroit Edison Company, presented papers giving actual operating data on the performance of 11 condensers of different designs, ranging from 16,000 to 64,600 sq.ft. of cooling surface and serving turbines ranging from 9,000 to 50,000 kw. These condensers have been operating for a period varying from one year to fifteen years. The test data are in some cases taken from plant operating logs and in other cases from tests.

Mr. Ricketts presents curves showing average monthly values during a year of the quantity of steam condensed, the temperature and the quantity of circulating water, the volume of air removed from the condenser, the actual vacuum maintained and the heat transfer coefficient.

Mr. Chatel's paper gives valuable data on the effect of cleaning condensers. He describes a method of cleaning by "baking," that is, by draining the water side of the condenser and holding the surface at 180 deg. F. for approximately five hours. The condenser is subsequently flushed with cold water, and through the combined action of the long period of dry heating and the sudden chilling of the tubes, the accumulation of sediment and scale on the water side is dislodged and washed off. This method, however, is restricted in its effectiveness, since some types of scale become more firmly affixed to the metal surfaces, rather than dislodged, by a method of this type. Accordingly, Mr. Chatel reports that the baking method is used in only one of the four plants of his company. The other plants clean tubes by driving rubber plugs through them, under water pressure. Curves are presented to show the improvement in heat transfer and exhaust pressure, due to cleaning. In some cases the gain in exhaust pressure approaches four-tenths of an inch of mercury, and the curves indicate that a gain of more than one-tenth of an inch of mercury is common. In some cases the condensers are cleaned weekly, whereas in others plants or at other seasons of the year longer intervals may be used. Mr. Chatel says that in his practice a condenser is considered ready for cleaning when the pressure has risen 0.25 in. of mercury above that shown by curves of normal performance. After cleaning it is evident that the heat transfer rises while the steam pressure decreases, a condition which, under similar operating conditions, can exist only with an improvement in the condenser.

Comparison of performance of identical condensers in various plants indicates that the degree of cleanliness achieved is not the same, perhaps due to difference in water conditions.

Mr. Chatel compares his condenser performance by plotting curves showing the coefficient of heat transfer, the power used by the circulating pumps, and the undercooling of the condensate, all plotted as ordinates with the pounds of circulating water per pound of condensate per thousand square feet of surface as abscissa.

Mr. Ricketts' closing remark is that the data presented are probably not sufficiently comprehensive to warrant definite conclusions as to the relative excellence of the designs tested, but that it is believed that they will provide condenser designers and operators with food for thought. This observation applies as well to the other papers on the subject, and all who are concerned with the design and operation of surface condensers should secure these papers and study the data set forth.

Discussion on Condensers

G. L. Kothny, of the C. H. Wheeler Manufacturing Co., discussed Mr. Ricketts' results in detail, pointing out the importance of circulating pump power and the like. He remarked that much of Mr. Bancel's material was published by Lord Weir in 1912, when he set forth the principles that Mr. Bancel employs.

P. E. Reynolds questioned the validity of Mr. Bancel's data, and maintained that the two-pass condenser is not inferior to the single-pass condenser. He mentioned the importance of considering the steam used for air ejectors, and the difficulty of measuring the temperature of low pressure air.

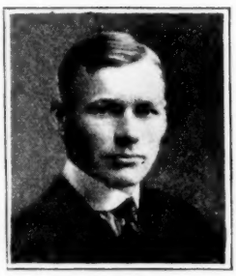
H. G. Thielscher, of McClellan & Junkersfeld, and C. D. Zimmerman, of the Cleveland Illuminating Co., presented detailed studies of some of the data presented. D. W. R. Morgan, of the Westinghouse Electric & Manufacturing Co., considers condensate temperature unimportant in modern stations with regenerative feed heating, but believes it essential to develop a generally accepted standard of air removal performance. What constitutes the best condenser, he said, is a matter of arithmetic, including first cost, pump power, etc. He said that the conditions of hydraulic flow conditions in the water-boxes of the condenser are of great importance.

George A. Orrok remarked that no condenser is ever loaded up to its heat transfer capacity. It merely handles the heat that is to be absorbed.

V. E. Alden, of Stone & Webster, discussed the design of condensers from the point of view of the operator and the plant designer, who desire good results with minimum costs in money and power and maintenance. He alluded to methods of condenser design that lead to rationally justifiable results.

In closure, Mr. Bancel remarked that the power used by a reciprocating air pump is negligible, but that the steam used by a steam-jet ejector is of much greater significance, and should never be neglected. Mr. Ricketts said that his paper quoted tube renewals merely to show how many tubes were plugged during the tests, and that no other use should be made of those data. Mr. Chatel remarked that the latest practice of his company does not represent their judgment as to what is best in general, but simply their choice for their own operating conditions.

Boiler Furnace Radiation



W. J. Wohlenberg

THE paper on "Influence of Radiation in Coal-Fired Furnaces on Boiler Surface Requirements," and a simplified method for its calculation, by Prof. W. J. Wohlenberg, of the Sheffield Scientific School at Yale University, and E. L. Lindseth, of the Cleveland Electric Illuminating Co., is a continuation of the study by Wohlenberg and Morrow, presented at the 1925 spring meeting of the Society in Milwaukee and published in the Transactions.

The paper, with its two principal parts and seven appendices covering 86 pages, sets forth an elaborate mathematical analysis of the effect of radiation in stoker-fired and pulverized coal furnaces of three different sizes, with five different proportions of cold and hot internal surface, and with three fuels—a high-volatile coal, a low-volatile coal and pure carbon. The results are embodied in curves which form the greater part of the 46 illustrations and picture clearly the relations of the several quantities considered.

The study considers the rate of energy liberation per cubic foot of furnace volume, the temperature to which combustion air is preheated, the type of coal, and whether it is pulverized or stoker fired, in their influence on the total surface required, and on the relative proportions of radiation and convection surface. The general method of attack is outlined in detail, but in mathematical language that does not lend itself readily to abstracting.

The appendices, seven in number, discuss auxiliary and subordinate topics referred to in the body of the paper.

After discussion by B. N. Broido and J. G. Coutant, who agreed in praising the paper, and simply asked questions as to method and results, Mr. Lindseth presented the authors' closure. The temperatures of the paper, he said, are averages for the furnace, the authors realizing that near the walls the gas is cooler than in the center of the furnace. He said that Schach's method for determining gas radiation seems to be the best available. For questions concerning the transparency of the gas to radiation, he referred to the earlier paper by Wohlenberg and Morrow.

E. L. Lindseth

V-Notch Weir Accuracy

D. R. Yarnall described the calibration of the large V-notch weir meter installed in the Richmond Station of the Philadelphia Electric Company for testing operating meters. The installation will shortly be described in *Power*. The calibration was carried out in the laboratories of the Civil Engineering Department of the University of Pennsylvania with numerous precautions to secure dependable results. The weir meter discharged to weighing tanks capable of weighing at a rate as high as one million pounds per hour without difficulty, and

a circulating pump returned the water to a constant-level head tank from which it passed through a regulating valve to the weir meter.

The results indicate that the coefficients published by James Barr in 1910 are somewhat high. It appears that with proper coefficients the V-notch weir is susceptible of an accuracy within one-half of one per cent, since all the tests fall within this range.

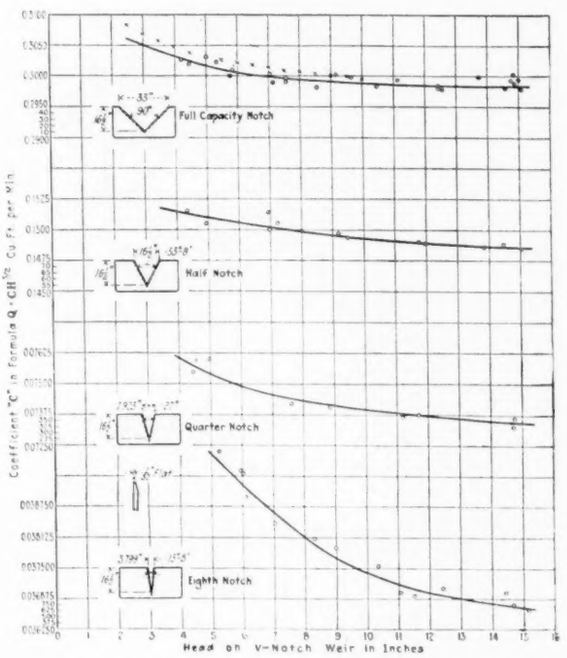
It is planned to conduct further tests extending to 20- and even 24-in. heads. Since the curve appears to flatten out at 15 inches, it is expected that coefficients for higher heads will differ only slightly from those for 15-in. heads.

PROFESSOR PARDOE, who conducted the laboratory work, said that the water weighing was accurate to one 1 in 15,000 lb., the capacity of the scales. While in the abstract, the orifice is more accurate for high flows, the V-notch weir provides a convenient means for measuring flows varying between wide limits. Professor A. G. Christie inquired concerning the method of setting the hook gage zero, and asked about the effect of discharge chamber water level.

J. M. SPITZGLASS, of the Republic Flowmeter Co., pointed out that, while the coefficients show the true accuracy of the weir proper, it is not a true standard for calibrating other meters. If its indications are reduced by mechanical recording or indicating mechanism, its accuracy suffers, while if observations are to be made with scientific precision, they might as well be made directly on the meter orifices themselves.

C. C. TRUMP, of the Atlantic Refining Co., inquired concerning the effect of viscosity, and reported that his observations indicate that weir discharge increases with viscosity, due to reduced contraction of more viscous liquids. For handling liquids over a considerable range of viscosity, the rounded orifice is more consistent than the sharp-edged weir, and he mentioned an orifice plate with numerous small orifices so arranged that the discharge is proportional to the head.

In closing the discussion, Mr. Yarnall described the careful methods of establishing the zero of the hook gage, and said that he had purposely omitted mention of indicating or recording mechanism, since his object was to present data for the weir itself. The discharge chamber level, he said, should be below the weir apex by a distance not less than the head of water above the apex. This, he said, will assure accuracy, although a closer approach may not introduce serious errors.


Full Capacity Notch
Half Notch
Quarter Notch
Eighth Notch
Coefficient "C" in Formula Q = CH^3/2 Cu. Ft. per Min.
Head on V-Notch Weir in Inches

Test results of the V-notch weir meter calibration

Crosses for the full capacity notch indicate values obtained by James Barr in 1910.

Boiler Feed Water Research Committees Present Reports

FIVE national technical organizations are co-operating actively in a study of the various processes employed in the purification of feed water in steam power plants and on railroads. This joint research committee on boiler feed water study is sponsored by the American Railway Engineering Association, the American Water Works Association, the National Electric Light Association, the American Society for Testing Materials and the American Society of Mechanical Engineers. There are nine subcommittees under the direction of an advisory committee headed by Sheppard T. Powell, consulting engineer.

Because of the importance of this work the Thursday afternoon power session was devoted to the progress reports of the various subcommittees.

Sub-Committee No. 1 (R. C. Bardwell, chairman) submitted an extensive discussion covering technical points in connection with sedimentation, pressure and gravity filters, deconcentrators, and continuous blowdown apparatus.

Clarence R. Knowles, chairman of subcommittee No. 2 on water softening by chemicals (external treatment), gave the results of studies comparing continuous and intermittent lime-soda water-softening plants and a discussion of the economic value of lime-soda softeners preliminary to Zeolite softeners or evaporators. The first study seems on the whole to favor the continuous type of softener over the intermittent softener for power-plant use.

Several factors, according to this report, determined the advisability of lime-soda softening preliminary to Zeolite softeners. Most of these favor such combination plants more frequently in the large power plants. One purpose of the pretreatment is to reduce the blowdown required by cutting down the amount of sodium salts in the boiler feed water. Obviously, the blowdown loss is more serious with large boilers operated at high rating. Such boilers are therefore more likely to justify the lime-soda pretreatment.

Another factor tending to make the lime-soda pretreatment more desirable in large plants than in the small, according to this report, is the fact that the cost

of additional equipment for a thousand gallons of water treated daily is much lower in large installations.

As is the case with Zeolite softeners, pretreatment with evaporators pays better in large installations than in small ones, but is rarely worth while for less than 10 grains of hardness.

Priming and Foaming

C. W. Foulk, chairman of subcommittee No. 3 on Zeolite softeners, internal treatment, priming and foaming and electrolytic scale prevention, presented a report confined to the subject of priming and foaming. The report deplored the confusion existing in the definition of these terms. It mentioned as the two principal methods of reducing foaming—first, reducing the concentration of sodium, suspended solids or other offending substances by blowing down the water, and second, the use of anti-foam compound produced by emulsifying castor oil with starch and other ingredients.

Prof. A. E. White said that subcommittee No. 4 was compiling a bibliography on condenser tubes.

Embrittlement

In an extensive report by its chairman, Prof. A. G. Christie, subcommittee No. 6 on the embrittlement of metals reviewed the experiments and discussion on the subject to date and showed on what points there was general agreement. As this subject has already been treated extensively in *Power*, it will suffice to summarize here the final recommendations of the subcommittee as follows:

1. In view of the wide diversity of opinion on the cause of embrittlement, extensive research should be started to determine the influence of all possible contributing factors.

2. Plans for such research should be formulated to give recognition to causes of embrittlement other than those that may result from the use of waters in which high concentration of caustic soda is potentially possible.

3. Not only must the causes of embrittlement be determined, but means of preventing its occurrence under all conditions should be developed as soon as all contributing causes are known.

4. Since the plate ligament or the rivet in riveted joints may be set beyond the elastic limit of the metal, a study of other means of joining plates such as welding, is a logical step in the elimination of embrittlement troubles.

5. This research may be carried out in university laboratories, but funds must be obtained to finance this experimental work.

6. This committee should be continued to co-ordinate the research work and report developments in the study of embrittlement of metal.

Water Pollution

In the aggregate power plants suffer an enormous yearly loss from impurities artificially introduced into raw-water supplies, according to the report of subcommittee No. 7 on municipal water supply in relation to boiler use, of which V. B. Siems is chairman. In a few cases the city itself is the offender, adding sulphuric acid to water prior to alum treatment. The greatest loss comes from trade wastes, such as acid from the pickling vats of steel mills or oil refinery sludge, textile-plant waste, domestic sewage, etc. The committee reported the need of further study in co-operation with state and government bureaus.

To carry out a program of corrosion study, it will be necessary for subcommittee No. 5 to obtain the full-time service of a technical man who has had previous experience in working out corrosion problems, according to the report presented by the chairman, Frank N. Speller. The committee is now considering this plan and ways and means by which it may be carried out, although nothing definite has yet been decided on.

Harold Farmer, chairman of subcommittee No. 8 on standardization of water analysis, recommended that the committee be enlarged and that the standards of analysis developed should follow as far as possible those of the American Public Health Association, which are already widely used.

Abstract Service in Operation

As chairman on the subcommittee No. 9 on bibliography, Prof. George A. Stetson reported the satisfactory completion of an arrangement with the "Engineering Index," published by the American Society of Mechanical Engineers, whereby the regular editorial staff of that body would select suitable items for abstracts. These are sent monthly to the chairman of the bibliography subcommittee. From these the most significant items are chosen and put in mimeograph form for distribution through the courtesy of the A.S.M.E.

Discussion Brings Out Practical Points

In the discussion Russell C. Jones, vice-president of Griscom Russell Co., offered to assist subcommittee No. 2 in getting data on chemical treatment ahead of evaporators. He felt that more complete data would modify the conclusion based on the questionnaire sent out by the committee.

Prof. A. E. White reported an interesting discovery recently made by a tube manufacturer. It was found that tubes containing one-half per cent nickel were free from scale, whereas ordinary tubes scaled heavily. The experiments were made on locomotives in Canada. The reason for this is not yet known.

Discussing the report of subcommittee No. 3, E. M. Partridge, of the Paige & Jones Chemical Co., said that colloids in small quantities had a marked effect on scale production. When the compound used, he said, contained certain organic compounds less scale was formed and that formed was softer.

Telling of his practical experience with embrittled boiler drums, V. M. Frost, of the Public Service Electric & Gas Co., New Jersey, said that excessive stress was indicated in all the cases of embrittlement with which he was personally familiar. They did not in every case know about the water composition.

Comments made by G. D. Bradshaw, Andrews-Bradshaw Co., and Mr. Trump of the Solvay Process Co., indicated that bolts were embrittled when they showed a deposit of certain salts and were at the same time subjected to strain.

In closing the meeting Mr. Powell urged co-operation by industrial users to secure the cleaning up of polluted streams. He also called attention to the existing confusion in the matter of standards of water analysis. At the present time, he said, railroad men and engineers of stationary plants do not talk the same language. Even tentative standards would be better than none.

Petroleum Session Considers Boiler House Problems

IN A central station the boiler plant receives much attention because it is one of the obvious portions of the station. In the industrial plant, however, the boiler room is less obvious and improvement has been too slow in many cases. So it is very desirable that possible savings in this part of the plant be brought to the attention of those interested.

Huge Savings Possible in Oil Refinery Boiler Houses

IN A paper presented at the Thursday afternoon petroleum session, H. A. Ross, steam engineer with H. S. Bell, Warren, Pa., painted a dark picture of present-day conditions in the boiler houses of small- and medium-sized oil refineries. He placed the average boiler efficiency in such plants below 50 per cent. The bright side, as pointed out by Mr. Ross, is the possibility under these conditions of making substantial savings, averaging about $20,000 per year for the typical medium-sized refinery.

A summary of Mr. Ross' main conclusions follows: While the oil refiner may not transgress more than the average small industrial plant owner in terms of the percentage waste of coal, the actual figures in dollars are far more serious because of continuous operation 24 hours per day and 365 days per year.

Inefficiency penalizes the small refinery in competition with the large one, which generally operates its boiler plant on a fairly efficient basis.

The small refinery is generally managed in all its departments by one man. Although his small boiler house, containing 3,500 to 4,000 sq.ft. of return-tubular boilers, burns perhaps twenty tons of coal per day, the loss is serious because the boiler efficiency is down around 45 per cent. The auxiliaries consist of two duplex feed pumps and something that goes by the name of a feed-water heater. The coal- and ash-handling equipment generally consists of nothing but a wheelbarrow. Instruments are entirely lacking. All this is due to the neglect of the manager, who gives most of his consideration to the refining equipment, as long as the boilers produce enough steam to keep the refinery going. Any system of records or checks on boiler-house operation or efficiency is, of course, not even thought of.

About 40 per cent of the steam produced is required for mechanical equipment, the rest being used for processing and heating purposes. There is frequent difficulty due to shortage of steam to satisfy the refinery demand. This is caused by insufficient boiler capacity, unscheduled peak demands and inefficient boiler operation.

Temporary changes are made to meet the necessity of keeping the refinery going. As often as not the makeshifts become permanent features. Several ill-considered changes or additions are made in the average year. The cumulative effect of conducting a refinery in this manner is not only low efficiency but damage to the equipment. This, in turn, finally results in curtailment of production. When this occurs, new boilers are rushed into place without considering the ability of the existing stacks to handle the increased volume of gases or of existing pumps and heaters to care for the increased load.

In addition to the loss due to inefficient production of steam there is a large waste in its use. Pumps and engines are generally scored and leaky. In many refineries all the exhaust steam is wasted to the atmosphere. This is sometimes due to the erroneous idea that high steam pressures are needed at the stills. It has been conclusively proved that 20 lb. gage is sufficient for this purpose.

This loss can be prevented by connecting all exhaust lines to a header maintained at 20 lb. gage by running in the necessary additional live steam through a reducing valve. All process and heating steam is taken from this line. Additional heat may be picked up without fuel cost by inserting superheaters in the waste-gas flues of the stills to superheat the steam used by the stills.

Where the electric bill exceeds $500 a month, substantial savings can be made by the use of back-pressure turbo-generators exhausting to the low-pressure line. Modern water-tube boilers may be installed (the present boilers are generally old and nearly obsolete) to furnish steam at 250 lb. or higher to turbines exhausting to the old steam-distribution system at 60 to 80 lb. After this has served the pumps and other old equipment, the exhaust from these can be carried to the stills and other processes.

As most small refineries now use 100 per cent make-up and dose the boilers with compounds, great savings are possible by the installation of devices to recover condensate and treat the makeup scientifically. Finally, a first-class man must be put in charge of the boiler plant if efficiency is to be maintained.

Surveys made in over twenty small- and medium-sized refineries, indicate that an average saving of over $8,000 a year can be made simply by improving boiler efficiency. Conservation of steam now wasted will save another $8,000 and the byproduct production of electric power another $6,000. In all, the total saving would average about $22,000 a year.

Discussion

In discussing this paper, Dr. D. S. Jacobus, of the Babcock & Wilcox Co., complimented the author on his effort to point out the waste in the boiler rooms of many industrial plants. The tendency in these plants today is toward higher efficiency and higher class labor. It was also pointed out in the discussion that the large refineries took the step indicated by Mr. Ross ten years ago and thus the conditions pictured apply to only a minority of refinery plants.

New Developments in Coal Research Pictured by British Scientist

Doctor Lander, in Thurston Lecture, Tells How Scientists on Both Sides of the Atlantic Are Working Toward a Solution of the Difficult Problems of Coal Utilization

DR. CECIL H. LANDER, Director of Fuel Research, Department of Scientific and Industrial Research, London, England, arrived in the United States early in November and was brought prominently before the engineers of this country by his address at the International Conference on Bituminous Coal recently held in Pittsburgh. As his last public act before returning to England, Doctor Lander delivered the annual Robert Henry Thurston lecture on Tuesday afternoon before an audience that filled the main auditorium of the engineering societies building. His subject was "Recent Developments in the Science of Coal Utilization." Doctor Lander's address was well designed to give to the mechanical engineers a picture of the foundation scientists are laying for advances in fuel technology. A brief abstract of certain portions of his address follows:

Dr. Cecil H. Lander

"The science of coal utilization deals with the stepping up of the thermal availability of the raw coal, and no avenue should be left unexplored which may lead to improvement in our methods. Study must begin with the raw materials and may even involve speculation as to events and happenings of millions of years ago.

"It is only comparatively lately that the number of scientific workers who have been studying the different aspects of the constitution of coal has been at all commensurate with the importance of the subject. At the present time greatest interest is being manifested, both by technologists and the general public, in all methods by which coal may be transformed into gas, tar or oil, while the production of 'metallurgical' and smokeless fuel is receiving the closest attention.

"Study of coal seams by means of X-rays is yielding information of particular value in connection with the purification of coal. The utilization of X-rays for the examination of the products from washeries has proved of considerable practical value, permitting the detection and removal of lump impurities.

"Sinnatt, who began to work on the carbonization of coking coals in 1917, has found that when particles of coking coal are brought into an inert atmosphere at temperatures exceeding about 500 deg. C., the carbonization of coal is accompanied by the production of minute hollow spheres, which he has termed 'cenospheres.' Using particles of coal 0.3 mm. in diameter and exposing them under suitable conditions to a temperature of 600 deg. C., cenospheres of about 0.5 mm. diameter are formed, while if the temperature be 800 deg. C., the diameter is about 0.7 mm., and the volumes of the cenospheres are about eight times those of the original coal particles.

"Cenospheres are found under the microscope to consist of two main structures, a practically opaque skeleton or framework, to which the name 'lattice' has been given, and a thin transparent brownish film filling the interstices in the lattice, forming what have been termed windows.

"The coke produced appears to be eminently suitable for use in powdered-fuel plants, since it presents an enormous surface upon which combustion can take place. The bubbles, or cenospheres, are extremely delicate and easily crushed to a much greater degree of fineness, should this prove necessary.

"At the present time perhaps the most striking instance of the relation between science and engineering is afforded by those processes by which the coal substance is transformed into liquid fuel by the method of synthesis or hydrogenation. These are of particular interest to the present gathering, since they may possibly supply or supplement in the future materials which at the present time can be developed only from natural oil wells. They also require in their development the arts of the mechanical engineer in the construction and types of apparatus which will deal with extreme pressures, accompanied by elevated temperatures. The processes of greatest interest are those developed by Fischer and Bergius in Germany, and Patart and Audibert in France."

It is understood that a large-scale unit to operate on the principle developed by Doctor Bergius is now in course of erection for the German dye-stuff group for the treatment of lignite and another in the Ruhr under the auspices of the *Gesselschaft Fur Teer Verwertung*. The working results of these plants will be awaited with the keenest interest.

Refrigerating Engineers Encourage Research

AT VARIOUS times the American Society of Refrigerating Engineers has been criticized as devoting too much time to purely commercial interests to the general exclusion of engineering and research. Such objectors would have found nothing but praise for the many papers presented at the twenty-second annual meeting of the society at the Hotel Astor, New York City. The meetings, which continued from Dec. 6 to 8, were distinguished by the quality, from a purely engineering viewpoint, of the several papers presented.

The retiring president, L. Howard Jenks, welcomed the members in a short address in which he stressed the point that the refrigerating industry has a greater future, especially in those countries, such as China, where the cold-storaging of food products is unknown.

The Corrosion Committee, created by the Society some time ago, then presented a report on the prevention of corrosion in brine tanks.

The effect of alkalinity, oxygen concentration, velocity and other factors had been studied before, so the work consisted mainly of searching for retarders, which, when added to the brine in the proper concentration, would decrease or eliminate corrosion of both bare and galvanized metal. The influence of sodium chromate on the corrosion of iron and steel by calcium brine was discussed. It was found that the addition of sodium dichromate to the brine gave a protection to iron and steel when the dichromate was neutralized, that is, converted to sodium chromate by the addition of caustic soda. In other words, sodium chromate is a more efficient retarder for iron and steel than the dichromate per unit of chromium in the brine. However, because of its common use in the arts, the dichromate is cheaper and more readily available than the chromate. It is, therefore, advisable to purchase the dichromate and neutralize it in the brine tank, rather than to buy a commercial mixture.

If the 76 per cent commercial flake caustic soda is used for neutralization, 35 lb. should be added for each 100 lb. of dichromate. Slightly less than this amount of caustic is necessary if the brine is alkaline before treatment.

The most effective concentration of dichromate to use is 200 lb. per 1,000 cu.ft. of brine. It is not advisable to use this salt in open systems, however, because the workmen handling the brine are liable to be affected by "chrome itch." This can be avoided if the men will observe cleanliness.

Tests on galvanized material, brass, bronze and Admiralty metal showed that about 90 per cent protection to these metals could be obtained by the use of dichromate neutralized with caustic soda.

For open systems bi-sodium phosphate was recommended for open brine tanks, although the results were not so good as with the chromate. On the other hand, tests revealed that sodium silicate was of little use as a corrosion preventive.

Data on Operating Costs

THE subject of cold storage was touched upon by GEORGE A. HORNE in a paper entitled "Cold Storage Operation Data." This paper dealt with the cost of operation of a New York City cold-storage plant on the basis of mean ton-day of refrigeration. These costs were as given in the tabulation:

ANALYSIS OF POWER PLANT COST PER MEAN TON DAY OF REFRIGERATION

Direct Charges:	
Maintenance, labor and materials	$0.260
Lubricants	0.007
Light and power (Electricity)	0.530
Calcium chloride	0.006
Ammonia	0.000
Operating salaries and wages	0.350
Miscellaneous supplies	0.027
Total direct charges	$1.180
Indirect Charges or Overhead:	
Interest, 6 per cent on investment, including building and machinery	0.344
Taxes, 5 per cent depreciation on machinery, 1½ per cent on building	0.238
Insurance	0.004
Total indirect charges	0.621
Grand total cost per ton-day	$1.801

The author pointed out, however, that these costs were high owing to the type of machinery and the high rental. In a second more modern plant located in a low rental building, the costs were about one-half those given.

FRED OPHULS, Consulting Engineer, in a paper on "Manufacturing Expense Ice-Making Plants," outlined a plan of accounting whereby the several items in the cost of ice manufacture may be segregated. He offered the novel idea that the cost of generating power in a large central station be taken as the standard whereby to gage the operating effort of the ice-plant engineering force.

Unfortunately, data on the segregated manufacturing expense of modern electric power plants is difficult to find. Taking advantage of the information it was possible to gather, it was decided for the present to divide the electric power cost into its items of manufacturing expense according to the following percentages:

	Per Cent
Salaries and wages, power-house	23
Fuel	30
Oil and waste	2
Sundries	2
Machine repair, labor	6
Material	6
Taxes	2
Insurance	2
Depreciation	27

This segregation of the electric power cost must vary somewhat when electric power is purchased from various public-service companies. In all these first attempts, it is better to start with something, however, incomplete the data may be. When it is found that such a segregation of electric power cost is valuable for this analysis, the power companies may help to prepare schedules themselves for this purpose.

The author then gave tables showing an analysis of costs in steam and electrically driven plants.

A comparison of the figures in the tables shows conclusively that an adjustment of the actual operating expense is necessary in order to make it comparable among several plants, particularly when one wishes to compare steam-driven and electrically driven plants. Such a comparison is justified, and there should be means and ways by which this comparison can be made. Such a comparison will show very clearly why there is such an advantage in electrically driven plants, provided the current can be purchased at a reasonable cost.

Determining Amount of Condenser Water

"ECONOMIC Balances in the Design and Operation of the Ammonia Condenser" was the title of a paper by T. K. Sherwood, Department of Chemical Engineering, Massachusetts Institute of Technology. The author's purpose was to establish the relation of the heat transfer to the water velocity in ammonia condensers, and thereby deduce the influence of the amount of water and scale upon the tonnage output of the condenser. It was pointed out that the resistance due to scale was constant, regardless of the water rate and that as the condenser tubes become more and more scaled or corroded, the resistance to heat transfer continually increases, so that for the same load the temperature difference in the condenser must be increased, causing a corresponding increase in head pressure and in compressor horsepower. In the course of two or three months the heat transfer coefficient may be reduced to considerably less than half the value obtained when the tubes have just been scraped. This means that, unless the load is reduced or the water rate increased, the necessary temperature difference must be more than doubled, causing an increase in compressor horsepower.

The temperature difference may be reduced by cleaning the condenser, causing a corresponding reduction in power requirements, and a balance must be struck between the power saving and the cost of cleaning. The determination of the optimum cleaning cycle has been worked out for the case of power-plant condensers, but so far as the author was aware, its importance has never been emphasized for the case of the ammonia condenser.

The determination of the optimum time between successive cleanings resolves itself into the determination of the minimum average daily sum of the cleaning cost plus that part of the power cost attributable to the rusting of the condenser. In order that a formula may be derived, the following symbols are introduced:

c = Total cost of each cleaning of the condenser in dollars;

x = Optimum period between cleanings, days;

p = Average daily increase in horsepower due to the rusting of the condenser tubes;

d = Power cost in dollars per hp.-day.

Then the total of the two variable costs in question, as dollars per day, will be

$$\frac{c}{x} + \frac{p\,x\,d}{2}$$

and by differentiation this sum is found to be a minimum when

$$x = \sqrt{\frac{2c}{pd}}$$

A number of factors affect the determination of the optimum water rate for the condenser, and no simple formula can be written for the total costs. As the water rate is increased, the necessary temperature difference is decreased, owing to the reduction in the over-all resistance to heat transfer. At the same time the temperature rise of the water in the condenser is not so large, so that the condensing temperature may be reduced by an amount approximately equal to the reduction in the arithmetic mean average water temperature. However, the cost of pumping the water and of the water itself, increase as the compressor power is decreased.

Household Refrigerating Machines

SEVERAL papers dealing with household refrigerating machines were presented. According to the author of one, L. A. Phillipp, assistant investigator, Engineering Research, University of Michigan, a Kelvinator compressor having a cylinder $1\frac{13}{16}$-in. bore by $1\frac{1}{2}$-in. stroke had a volumetric efficiency of as high as 85 per cent when the discharge pressure was 35 lb. per sq.in. and ranging down to 45 per cent with a discharge of 150 lb. Further tests of this unit showed a horsepower input of approximately 0.25 per 100 lb. of refrigeration, or a power consumption of 6 hp.-hr. to perform a refrigerating duty equivalent to the melting of 100 lb. of ice.

In a second paper by L. A. Phillipp and C. C. Spreen, the latter chief engineer, Kelvinator Corporation, a method of rating household machines was outlined.

Provided the heat-transmisson coefficient of a refrigerator is known, the mechanical cooling unit, with which the refrigerator is equipped, can be rated by knowing the running time of the compressor per 24 hours. It was recommended that a machine be rated at one particular room temperature, say 80 deg. F. If the running time has been determined at a different room temperature, the ice-melting capacity can be calculated at these temperatures, but as an absolute method for comparing the equipment of various manufacturers it seems best to select one standard temperature. This method of rating is practical, in that it is experimentally determined under actual conditions.

Other Activities

OTHER papers on heat transfer were presented at the joint meeting with the American Society of Mechanical Engineers on Tuesday afternoon, abstracts of which are given in the reports of the latter society on another page.

On Tuesday evening the annual dinner was held at the Astor at which, besides the retiring and incoming president, the guests of honor were Dr. Chas. E. Lucke, of Columbia University; Dr. J. R. Thomas, president Rutgers University; and Dr. Francis H. Green, Pennington School for Boys. After the dinner, dancing was indulged in by those remaining.

New Officers

Officers for the ensuing year are: President, Willis H. Carrier, Newark, N. J.; vice-president, Prof. Andrew J. Wood, Pennsylvania State College; treasurer, William M. Whitten, New York City; secretary, William H. Ross, New York City.

Fifth Power Show a Signal Success

Previous Years' Efforts Far Surpassed—Quality and Diversity of Exhibits an Outstanding Feature

THE POWER SHOW is a tangible proof that the manufacturers of power-plant machinery and allied equipment, have done their part. Everything that a power plant or an industry could possibly need for up-to-date efficient operation in the power line is available, and each item is thus available from a number of sources. Scarcely any detail of manual effort exists, that cannot be replaced at a profit with mechanical control. The human factor that is most responsible for unsatisfactory results can be eliminated to practically the vanishing point. The last vestige of excuse for high power costs or inefficient methods in the power plant of today has disappeared entirely, regardless of whether the plant be large or small.

Engineers and experts in power problems have suggested the advantages of higher pressures, of increased ratings, of maintenance by prevention, of automatic control, of performance check, of superheat and a thousand and one other possibilities of getting the most from a pound of coal, of checking trouble before it can start, of protecting vunerable points, of exposing to inspection units that are unavoidably weak. The manufacturers, as witnessed by their exhibits, have met each suggestion and have provided for every possibility. Further responsibility rests squarely upon the power plant operator and owner.

Boilers of a few years ago were built for only comparatively low pressures, not so today. Exhibit after exhibit now shows machined joints, precision manufacture, protection for points that must necessarily receive the greatest strains. Actual sections, working models, books full of evidence, were on exhibit, that would convince the most skeptical. Where a few years ago one maker kept his methods from another, at this show they were all on the table for the common good. From a structural and manufacturing methods point of view, the show is a liberal education to the visitor.

Superheaters were on display that had seen long and arduous service, taken from operating installations for the purpose of helpful education. All that one had to do was to ask and he would be shown the application of the superheater elements, as manufactured by a number of companies to any type of boiler.

The refractory manufacturers have probably been harder pressed to keep up with the march of power-plant progress. The Show again bears evidence of their remarkable contributions. When furnace temperatures passed the melting points of their materials, they developed special shapes for air-cooling and water-cooling arrangement, and their designs took into account the possibilities of using the heat absorbed in the cooling process.

When high-tension operation and single unit installations cut the available maintenance time, these refractory makers provided material for monolithic construction that can be rapidly placed, with brick arrangement that permits of quick replacement, with equipment for shooting plastic refractory materials into gaps and burned spots.

Where mechanical erosion takes place and where extreme temperatures are unavoidable, there are bricks and shapes that will stand all and more punishment than has so far been the top limit of hard usage.

Steel casing construction has called for high-grade insulation between casing and walls. Such insulation is available in many forms on display at the show. In one exhibit was a small retort, built of insulation. Inside, an electric element raised the temperature to 2,000 deg. Outside, a little over two inches away the surface would not burn the hand.

There were soot-blower exhibits of actual equipment. At one was a moving picture outfit to show operation. Turn on and off was clearly illustrated. Safety guarding was amply illustrated, control of the jets was pictured to show how the blow was stopped where it passed over the fire and where it met the zone of another unit so that no steam would be wasted. On a model in another exhibit was shown a whistle telltail to let the operator know that his steam was on or off in the element far above his head. Incidentally, the whistle acts as a drain when the blowing is completed, and at that, not so incidental either.

In every line progress was shown. Improvements and refinements to meet the demand imposed by the higher pressure now being adopted were much in evidence. Several valve manufacturers showed new lines designed for the higher pressures, among which were valves with drop-forged steel bodies and trimmings of stainless steel. Multi-stage feed pumps designed for pressures up to 850 lb. were also shown. In fact, a general picture of the progress and development in the power-plant-equipment field could be readily gleaned by a visit to the show and a study of the products exhibited.

The addition of heating, ventilating and refrigeration equipment, as well as machine tools and wood-making apparatus added greatly to the diversity and interest of the show.

The previous issue of *Power* gave a complete list of exhibitors with their chief products. It also mentioned a few exhibits of particular interest. The impossibility, within practical space limitations, of describing the 480 exhibits has made it necessary to pass over those that are standard equipment or a duplicate of previous years, in the present article mentioning only new equipment and improvements not yet generally known to the field. Exception to this rule is made in a few cases, where the exhibit is spectacular or outstanding in its field.

Some of exhibits as seen from the mezzanine floor

As the use of pulverized coal is one of the chief topics among engineers at the present time, much interest was taken in the equipment for burning coal in this form. Many improvements and refinements have been made to this class of apparatus during the last year, particularly to the unit-type pulverizer, with a view to increasing the reliability and reducing the operating and maintenance charges. Eight unit-type pulverizers in all were shown. In some cases only minor refinements had been found necessary, while in others material changes had been made.

A new design of Lopulco pulverized-fuel burner designed for use with forced draft, a new design of single feeder and a unit-type pulverizing mill, on which a number of refinements have been made since the last show, were exhibited by the Combustion Engineering Corp. in addition to its other pulverized-fuel equipment and mechanical stokers.

The adoption of a semi-steel casing, independently motor-driven feeder, ball bearings and an adjustable uniformly distributed air inlet at the fan suction were among the changes made on the unit-type pulverizer shown by the Erie City Iron Works. Practically the only change made in the Simplex Unit, exhibited by the Furnace Engineering Co., was the duplex fan, which has two independent impellers within a single cast-iron housing. The inner impeller, which is fitted with renewable blades, handles all the coal and a small amount of air, while the outer fan supplies the remaining amount of air necessary for combustion.

In the "Atrita" unit, shown by the Riley Stoker Corp., a new design of primary pulverizing element, a rearrangement of the secondary elements and a new type of fan with renewable blades were the principal refinements made in the machine since the previous show. This company also showed a three-retort underfeed Riley stoker, equipped with an improved type of driving gear and a grid inserted between the side bar and the tuyere blocks, to increase materially the amount of air supply to the fuel bed.

New in the field of pulverized-fuel burners was the combined oil and coal burner shown by the Engineer Co. This burner is of the turbulent type, in which the pulverized coal is admitted through spirally inclined vanes that give it a clockwise whirling motion. The air is admitted on both sides of the fuel stream with a counterclockwise rotary motion. The collision of the opposing fuel and air streams results in intimate mixture which burns with a short flame. A combined oil and pulverized-fuel burner was also shown by the Peabody Engineering Corp. This burner, which consists essentially of a narrow coal and air chamber, placed between the air register of the regular Peabody oil burner and the furnace, was at the Show a year ago, but it is only recently that certain experimental tests have been completed and the burner placed on the market.

Another burner of the highly turbulent type was the Calumet, exhibited by the Fuller-Lehigh Co. In this burner, which is designed especially for adaptation to the Bailey furnace wall construction, the primary air and pulverized coal are injected into the furnace horizontally through a long narrow vertical slot, between two tubes of the water-cooled wall. The secondary air enters through ports on either side of the primary jet, the ports being at an angle with the primary air and coal stream and staggered in relation to one another.

View along one of the main floor aisles

How closely electricity had become interwoven into the generation, transmission and distribution of power was much in evidence in the show. A large percentage of the booths had something on exhibition in which at least one function was performed electrically. This equipment ranged from a turbo-generator to a very delicate circuit in a measuring instrument that required a ten-thousandth of an ampere for its operation. For the power plant there were electrically operated meters of all kinds. Electrically operated flow meters and CO_2 meters and recorders were much in evidence, there being six different designs on exhibition. In boiler-room control equipment, of the eleven combustion-control systems shown, eight were electrically operated.

A combustion-control system that has not been exhibited before was that of the Leeds & Northrup Co., which was described in *Power*, Oct. 26 of this year. In this system the operating medium is a direct current, to which the combustion rate is proportioned. When the electric current is adjusted to 10 per cent of normal in the control system, the various devices that make up the system adjust the fuel and air supply automatically

to this percentage. An increase to 30 per cent of electric current produces a corresponding increase in the fuel and air supply.

The current adjustment is produced by a master regulator operated by changes of steam pressure. A diaphragm in this regulator is acted upon by the steam pressure and causes an arm to move over stationary contacts. In this way resistance is cut in and out of the control circuit and the current varied according to the steam demands on the boiler. In general, the regulator varies the current in steps of about 2 per cent and the maximum control current is about 0.5 ampere.

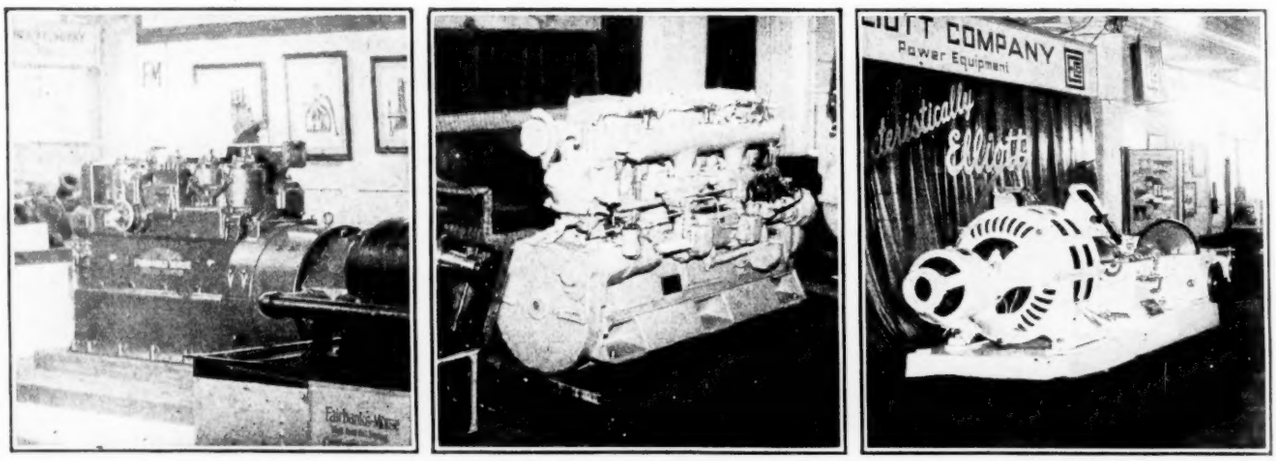
This company, in addition to exhibiting its new combustion-control system, had a new CO_2 meter and recorder, frequency recorder, generator-field temperature recorder, a B.t.u. recorder for measuring and recording automatically the heat in boiler feed water, and other recorders.

At the booth of the Smoot Engineering Corp. was demonstrated the function of a new excess feed-water pressure regulator in connection with a working model of its system of automatic boiler-plant control. The pressure regulator operates to vary the boiler feed-water excess pressure with the load and maintains the water level in the boiler constant. The excess pressure should vary as the square of the rating. One of the ways of obtaining this characteristic in the new regulator is to use the variation in pressure, across the gas passes of the boiler, which varies as the square of rating. This pressure, acting on a suitable diaphragm and lever operates the excess-pressure regulator on the feed pump to change the flow of water to the boiler in proportion to the rating. This regulator may be applied in combination with the company's automatic boiler-control system or independently of this system.

New equipment shown by the Allis-Chalmers Co. was an enclosed self-ventilated motor and a complete unit of Reyrolle switch gear. The motor is totally enclosed, is dust- and drip-proof and is arranged to be ventilated by air taken from outside the room in which the motor is located. Roller-type bearings are used, which are effectively sealed against dirt getting into the bearings and the oil from working out. A fan on the rotor draws air into the machine through the intake connection and forces it through and around the windings and core, after which it passes out the discharge connection, which may be carried outside the room.

The Reyrolle switch gear is of the armored type in which are included the busbars, current and potential transformers, cable potheads, disconnects and the oil switch with its auxiliaries. The oil switch can be removed from the rest of the equipment for inspection and repair. As the switch is withdrawn all live connections are automatically closed to eliminate any possibility of coming into contact with live parts. The busbar sections and current transformers and their connections are sealed in insulating compound, and the potential transformers are oil-insulated. This unit provides totally inclosed switching equipment for voltages up to 33,000, without the use of concrete switch or busbar compartments, which can be conveniently extended to meet the growth of the power system.

Another feature was the large number of motor operated or hydraulically operated valves. Practically every valve manufactured had an exhibit of this kind. Most of the operating equipment was of well-known designs that have been in operation for a number of years. A new hydraulic valve-closing equipment was exhibited by the Coffin Valve Co., applied to a Dow disk-arm pivot valve, used as a check valve in pump discharge lines. This check valve can be left in any position from full open to completely closed and will remain in this position as long as power is on the pump motor. A solenoid on the valve-operating mechanism is connected to the motor leads. If the power to the motor fails, the solenoid releases its core and causes the valve to close under the control of the operating mechanism, which prevents its slamming shut, as is characteristic of the conventional type of check valves.



Some of the prime movers seen at the show

At the Fairbanks Morse booth, among other equipment shown, was a 36-kw. Diesel-engine driven unit, consisting of a 40-hp. 4-cylinder engine and a 36-kw. direct-connected generator, operating at 800 r.p.m. It is planned to make units in rating of 27 and 18 kw. by reducing the number of cylinders on the engine to 3 and 2 respectively, and possibly a 9-kw. unit driven by a single-cylinder engine. The generator is totally inclosed and has ball bearings. The engine and generator are practically a single unit and make a very compact machine.

A new type of direct-current motor, a new alter-

nating-current motor and an improved type of electric flow meter were among the exhibits at the General Electric Co. booth. With the earlier type of electric flow meter developed by this company, it was necessary to provide means of compensating the meter for variation in voltage. In the new type, the magnetic circuits of the indicators and recorders are so designed that the accuracy of the meter is not affected by changes in voltage of the operating circuit.

The new type of alternating-current motor is equipped with ball bearings and is totally inclosed and self-ventilated. The ventilating air is drawn in at the center of the stator by fans on the rotor, and is passed over the windings and discharged at the ends. Suitable connections are provided for taking the ventilating air from outside the room in which the motor is located. On the direct-current motor a closed system of ventilation is used in combination with a system for blowing air over the outside surface of the motor to increase the radiation from the frame. The air inside the motor is continuously circulated by a fan on the armature. In this way the heat from the winding and other parts is rapidly transferred to the surface of the shell. The external cooling system blowing air over the outside surface of the shell provides a quick dissipation of the heat from the motor.

The new type of electric gas analyzer was shown at the booth of the Charles Engelhard, Inc., in addition to a line of electric pyrometers. One of the uses of the new analyzer is in connection with a CO_2 meter and recorder. The analysis unit consists of two platinum spirals wound on a quartz rod and inclosed in a quartz jacket having practically the same thermal conductivity as platinum and form two of the arms of a Wheatstone bridge. One of these spirals is sealed in nitrogen gas, while the flue gas is caused to flow over the other. The spirals are heated electrically, and the difference in heat conductivity of the two gases determine the difference in the resistance of platinum wires and the amount the bridge will be out of balance. When the analyzer is used in connection with a CO_2 meter and recorder, the out-of-balance of the bridge is a function of the per cent CO_2 in the flue gas.

Included in the Uehling Instrument Co. exhibit of meters and recorders was a new system of automatic control apparatus. A number of examples were shown of the new automatic control to demonstrate its many applications. The control unit consisted of a small motor and reduction gear and suitable relays for controlling starting, stopping and reversing. This control equipment is very sensitive and may be used to control humidity, temperature, flow, pressure, draft, water level, etc.

As in previous years the exhibits of high-pressure valves and fittings were extensive. A line of high-pressure motor-driven valves for 650 lb. and 750 deg. temp. was shown by the Chapman Valve Manufacturing Co., also a 30-in. atmospheric relief valve equipped with a hydraulic operating cylinder.

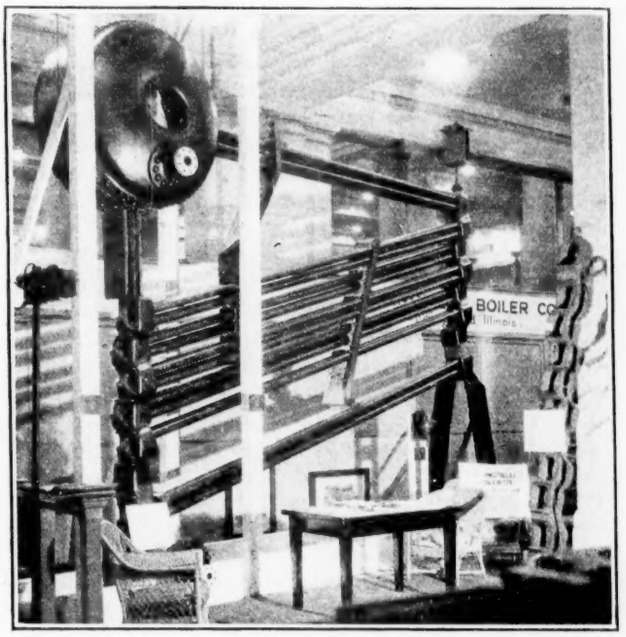
A new line of drop-forged steel valves in angle, globe, gate and check types up to 2-in. size and trimmed with exelloy stainless steel was shown by the Crane Co. In addition a new receiver-type separator was shown, in which the receiver is made from seamless steel pipe, thus eliminating the usual riveted joint.

The Lunkenheimer Co. showed a new line of all-monel-metal valves, also a line of steel valves for pressures up to 600 lb. with an improved type of disk and seat and machined guides which tend to prevent the disk touching the seats until the valve is practically seated.

The Reading Steel Casting Co. showed samples of a new line of steel valves embodying certain refinements, to eliminate as far as possible the warping of the seating surfaces when the valve is subjected to high temperatures in service. The new line is trimmed with rustless steel and will cover a broader field of application than the line heretofore made by this company.

A new type of swing gate valve with cast-steel body, designed for 400 lb. and 700 deg. temperature, was exhibited by Payne Dean. The valves are designed for operation by either air or electric motor and can be installed in practically the same space as required for the body of the regular type of gate valve, as the bonnet and stem are omitted.

The Edward Valve & Manufacturing Co. showed a new type of forged steel valves in which changes have been made in the design of the body to reduce as far as possible expansional and contractional stresses.



Section of high-pressure Springfield boiler

In the line of blowoff valves, a tandem arrangement consisting of an angle-type valve in series with a straightaway type for pressures up to 900 lb. was shown by the Yarnall-Waring Co. Also an improved type of spray nozzle and spray-pond fittings, as described in the Oct. 12 issue. A Yarway Lea V-notch recording meter was also shown in operation, giving a continuous reading of water flowing through a sectioned tank equipped with a hook gage attachment by which the meter can be checked at any period in its operation.

The Everlasting Valve Co., in addition to its line of blowoff valves, featured the Wylie Wilson boiler drawoff process, which has been brought out since the previous show. This process is designed to promote safety and reduce the wear and tear on the blowdown equipment. It was described in detail in the Sept. 7 issue of *Power*.

A new type of joint in which a copper-plate steel gasket known as the (Kell-Raph) is inserted between grooved flanges, was shown by the M. W. Kellog Co.

A refinement in the Sargol Weld Joint, for high pressures was a feature of the exhibit of the Pittsburgh Piping & Equipment Co. This refinement consists of extending the weld lip on each flange, approximately $\frac{3}{8}$ in. This tends to facilitate the welding process and reduce the amount of heat conducted into the flanges.

Outstanding in the field of high-pressure boiler-feed pumps, exhibited by the various manufacturers, was a 4-in. six-stage pump for 900 lb. pressure direct connected to a steam turbine, shown by the Ingersoll-Rand Co. The pump was equipped with a hydraulic balancing device to neutralize the end thrust on the pump rotor, and a Kingsbury thrust bearing.

A 4-in. eight-stage turbine-driven boiler-feed pump designed to deliver 600 gal. a min. at a temperature of 260 deg. against a pressure of 850 lb., was also shown by the Worthington Pump & Machinery Corp. A feature of this pump was an all-bronze casing.

A three-stage radojet air pump, with two barometric inter-condensers for producing a vacuum of 29.8 in., referred to a 30-in. barometer, with injection water of 70 deg. was shown by the C. H. Wheeler Manufacturing Co.

The Cochrane Corp. showed a new single-control valve for use with its strainerless filter to direct the flow through the filter for filtering, back washing and filtering to waste. This valve takes the place of four hand-operated valves. Another attachment was a flow controller to prevent the washing out of sand by excessive washing water and to show when the proper amount of washing water is being used.

New in the line of mechanical draft equipment were an induced and forced draft fan exhibited by the B. F. Sturtevant Co. The induced-draft fan is designed with special scroll inlets and connections to give a straight flow similar to a centrifugal pump. The fan impeller is designed for high tip speeds so that it can be direct-connected to a motor. To install the fan in existing breechings, it is only necessary to remove a section of the duct and insert the fan as the inlet and discharge connections are in line. The forced-draft fan is a propeller type fan with turbine drive on which guide vanes for the air have been added and which has increased the efficiency of the fan materially. Another new development with this company is a tubular air heater with lead-coated tubes.

In the field of air-filter equipment many new types were shown. The Midwest Air Filter, Inc., showed a self-cleaning type consisting of a series of demountable cells arranged in an endless chain. The chain in passing around the bottom sprocket dips into the viscosine and the dust is thus removed and a fresh surface of viscosine maintained.

The Drying Systems, Inc., showed, in addition to a rotary air filter, a constant-effect air-filter unit in which the filter screen is in the form of a belt, and the dust is removed and the viscous film renewed by submerging the lower end of the belt in the liquid.

In the self-cleaning type of filter, shown by the Reed Air Filter Co., the filtering media consists of staggered rows of streamline shaped tubes which are kept coated with "adhesive." The air in passing through the filter is cleaned by the impingement and scrubbing contact with the adhesive coated tubes. The adhesive surface is renewed by intermittent flushing of the tubes.

A new air filter of the cell type that has been used extensively in Europe and now being introduced in this country, was shown by the American Blower Co. Each cell is composed of ten or more perforated plates arranged in series. Each plate is pierced with the required number of apertures and covered on one side with a fireproof filament. In passing through the cell, any dust in the air is arrested and retained by the filament.

A feature of the Manning, Maxwell & Moore exhibit was an electrically operated safety valve produced by the Consolidated Safety Valve Co. The principal purpose of this valve is to reduce the usual 4 per cent blow-down, required by spring-load safety valves, to a negligible quantity. The valve is of the balanced design and is operated by opening and closing a small pilot valve by means of a solenoid, the current to the solenoid being made and broken with a special Bourdon spring gage control. Several types of the Reeves variable speed transmission were also shown by this company. The improvement made to this transmission during the last year includes an improved type of split splice block to facilitate the removal or application of the belt and a redesigning of the motor stand to make it adjustable to meet the dimensions of any standard motor frame.

As at former shows, the exhibits of boiler-room instruments were complete and extensive, and many improvements and refinements were to be found in practically every booth where instruments were displayed. Probably the most spectacular exhibit in the instrument line was that of the new Brown Electric Flow Meter. A large-sized working model of this instrument was shown in operation to illustrate the self-adjusting inductance bridge principle of the meter.

A rather unusual but practical exhibit was that of the Superheater Co. Here units taken from superheaters at the Hell Gate Station of the United Electric Light & Power Co., New York, and the Fordson Plant of the Ford Motor Co., Detroit, were displayed. These units have been in service for a number of years at high temperatures and under severe operating conditions, and from all appearances were still in excellent condition.

A new type of trap designed to handle large flows of condensate, was included in the exhibit of the Armstrong Machine Works. A feature of the trap is a piston-operated valve in the base of the trap which gives the trap an unusually large capacity.

A new bucket-type trap suitable for 400 lb. was also shown by the Wright-Austin Co. The trap is designed to be non-air binding and is fitted with monel-metal valve and seats which are reversible.

A feed-water regulator of comparatively recent development was shown in actual operation in the booth of the Atlas Valve Co. In this regulator (Campbell) the feed valve is controlled by the drop in pressure between two orifices through which a constant flow of steam and water is maintained from the water column, the pressure operating the feed valve being a function of the percentage of water in the steam passing through the orifices. Complete details of this regulator were presented in the Oct. 19 issue.

Parts of a new steam generator, features of which are the employment of long tubes of small diameter, and forced circulation were shown by the LaMont Corp. By virtue of the design this boiler is readily adaptable to high pressure and it is claimed weighs approximately one-quarter the weight and occupies about one-fifth the space of the conventional type. This generator was described in the Nov. 23 issue of *Power*.

Automatic Control in the Steam Plant

WHEN the first automatic substation went into operation about twelve years ago, it marked the beginning of a development that may eventually take the operation of all plants out of the hands of attendants. Considering substations and hydro-electric plants, automatic stations have become almost as common as those with attendants. This year a hydro-electric plant of nearly twenty thousand horsepower was put under construction, which is to be automatic in its operation. No doubt much larger units and plants will be put under such control in the near future, since there are no engineering limits to the application of such control.

Until recently the automatic steam station was nonexistent, but last year an automatic steam turbine plant went into operation. Although this unit may be considered an experiment, its operation is being studied with the object of extending such applications. The introduction of burning fuel in suspension under boilers and the developments in automatic combustion control have made close approach to the automatic plant possible.

In the modern steam plant the control of the power-generating equipment is largely automatic and the operators in many cases are so far away from the equipment that they cannot hear or see its operation. Boiler plants have been put under complete systems of automatic combustion control, and recording meters give a record of how the plants function, so that there is little left for the operator to do but duplicate the records and wait for something to happen. Why not go a little farther and take the control of the equipment out of the operator's hands entirely and design the plant so that when something does happen the control will take care of it automatically? The steam plant operated without attendants may never come, since by the very nature of these plants attendants will be required for certain routine work. However, there are many functions now performed by the human hands that could be as well or better taken care of by the control system.

Alex Dow

A WELL-MERITED tribute was the testimonial dinner tendered to Alex Dow last week by over half a thousand of his admirers.

There are doubtless human and personal traits that appeal more strongly to those who know Mr. Dow well, but to one who just looks on, the outstanding thing is the absence toward him of that rancor that so often marks the attitude of the proletariat toward those who have attained to large success.

A number of leaders in industry and finance have announced their discovery or conviction that they are parts of a great social-economical system with reciprocal and communal relations with other units of the system; that profit making should not be their primary purpose, but should come as incidental to and remunerative of service rendered.

Alex Dow's life has been molded upon this conception. He has attained to his position of leadership and eminence not by crabbing the road, not by ingenious devices for keeping just within the law, not by an obtrusive assertion of exaggerated self interest, but by the devotion of his splendid talents as an engineer and an administrator to the rendering of real public service.

He has not sought, nor would accept, any favors or advantages for his interests that did not comport with the public good. He has motivated and helped in the carrying out of many projects of research, development and common welfare. It is said of him that he always has time to see and hear a member of his organization, however lowly his station, consider his suggestion or do him justice. As a result his slightest wish commands heart-whole, interested service from those who see alike his honor as their profit.

And notwithstanding his grave responsibilities and unceasing activity he has had time to be a good fellow, a boon companion, one in whose company it is always a pleasure to be. Many more than those who were privileged to testify their regard by presence at his dinner will join in hoping for him a long continuance of enjoyment of the pre-eminence to which he has attained in the engineering profession in the electrical industry, in the affections of his friends and in the esteem of his fellow-citizens.

Data Needed on Air Preheaters

AIR preheaters have become a recognized part of the modern plant within a comparatively short time, and many new forms of such equipment have appeared on the market. Operating experience in large boiler plants with many of these new preheaters is meager. Those who have installed and tested air preheaters deserve great credit for their readiness to place their data before engineers.

However, there is much information of a practical nature that is now gradually accumulating, but which is available only to those who have actually installed and operated air preheaters. Much valuable information can be gained from such general records of operation. Data are particularly lacking on the maintenance necessary and on the rate of depreciation of the equipment or parts of it. Engineers will be interested in hearing experiences with corrosion which some fear may occur in the portion of the heater where the flue gases are coolest, particularly when high sulphur coals are burned.

There is considerable talk of the use of highly preheated air in furnaces. What are the limiting temperatures, both of air and flue gas to which air preheaters may be subjected? What are the highest average tem-

peratures now occurring in daily operation? Is the rate of deterioration greatly increased by these high temperatures when ordinary steel plate is used? If so, then more expensive alloys must be employed and this will reduce the economic saving from the air preheater.

There are also questions on the effect of highly preheated air on cast-iron stoker parts when these are used. At what temperatures will this iron start to grow? What is the life of cast-iron stoker parts with high preheat? When used with powdered coal, what is the limit of temperature to which the primary air may be preheated and mixed with the powdered coal before the latter becomes sticky and clogs up the burner mouths? Many engineers believe that it is desirable to pre-mix air and coal before they enter the furnace to secure highest economy. Does high preheat place a limit on this premixing?

The gains in boiler efficiency from the use of preheated air have been frequently stated. How much of this gain is offset by increased costs of fans, duct work and insulation around the air preheaters and the ducts conveying the air to stoker or powdered-fuel burner? Also, what is the most economical form of duct and the best method of insulating it against heat losses?

These are a few of the new problems raised by the air preheater. Discussions of any of these phases of the use of preheated air will be of much value to engineers. More general knowledge will tend toward removing doubts and thereby increase the application of this useful equipment.

The New Age of Coal

FOR years the magic word "electrical" has been applied to everything from razor blades to corn plasters. Perhaps it is too much to expect the word "coal" ever to attain such universal esteem, but the International Conference on Bituminous Coal, recently held in Pittsburgh, and the A.S.M.E. Session on By-Product Processing of Coal indicate a strong trend in that direction. Electricity is certainly the most refined medium for the distribution and utilization of energy, but it cannot rank in importance with coal, which is and will continue to be for hundreds of years our chief source of raw energy. It is unnecessary to repeat here the well-known demonstrations that petroleum and water power, important as they are, have no chance of usurping the throne of King Coal.

With known coal resources totaling at least 3,400 billion tons, more than one hundred times all that has been mined so far in the world's history, fundamental research on the nature and utilization of this potential wealth is a pressing necessity. It is only a starter to determine *how much* energy a given coal contains. Energy has "form value." A thousand thermal units are worth one sum in the form of steam, another as gas, and still another as electricity. They are worth more (just now) as a volatile motor fuel than as a heavy Diesel oil, more in a rich gas than in a lean one. Heat units have more value in the form of "low-temperature" briquets suitable for household use than as lumps of "high-temperature" coke.

These generalities are taken for granted by fuel technologists, whose attention is now concentrated on the scientific and economic problems involved in splitting the coal into various products useful for their energy content and form value. To these must be added such byproducts as fertilizers, medicines, dyes, etc., whose value is not thought of in terms of energy. The field is one to attract the best minds in pure science, engineering and business, because it is closely associated with applied physics and chemistry, and is concerned with the use and production of wealth.

A More Liberal Attitude Might Help Some

WHEN it comes to the discussion of our water-power resources by many legislators, it would appear that they ranked ahead of all other natural resources. On the other hand, the lack of support to administer the development of water power properly would lead to the belief that these resources were of little consequence. Ever since its inception the Federal Water Power Commission has been hampered in its work by the lack of funds to employ sufficient personnel. According to the Commission's sixth annual report, it has only two more persons on its staff than were temporarily supplied in 1920, at its formation. The appropriations in the meantime have been reduced from one hundred thousand dollars made available in 1921 to less than thirty-two thousand dollars for the current fiscal year.

For the seven fiscal years 1921 to 1927, the Commission will have granted licenses for over four million horsepower, and the aggregate expenditure by the Commission for all purposes has been slightly over one million dollars. If it is assumed that the average cost of the projects for which licenses have been granted is one hundred dollars, per horsepower, then the cost of the Commission has been less than one-quarter of one per cent of the total cost of the projects licensed.

In addition to granting permits and licenses for water-power developments, the Commission also deals with applications for transmission lines; has to determine if proposed power developments on non-navigable sections of streams will conflict with the interest of commerce on the navigable sections and consider applications for restorations to entry of lands within power-site reserves. In all cases of applications for permits and licenses, investigations must be made and reports submitted on the projects, the effects of the project upon others on the same streams must be decided and comprehensive studies made of technical and economic feasibility and adaptability of the plans to a comprehensive scheme of development of the stream.

On major projects administration responsibility continues after the license has been granted. Construction must be supervised and current determinations made of the actual investment by the licensee in the project. The costs incurred prior to the issuing of the license in the acquisition of lands and rights of property, and the cost of services must be ascertained. These latter claims may involve millions of dollars, and not infrequently a careful examination shows that a large number of such claims are invalid.

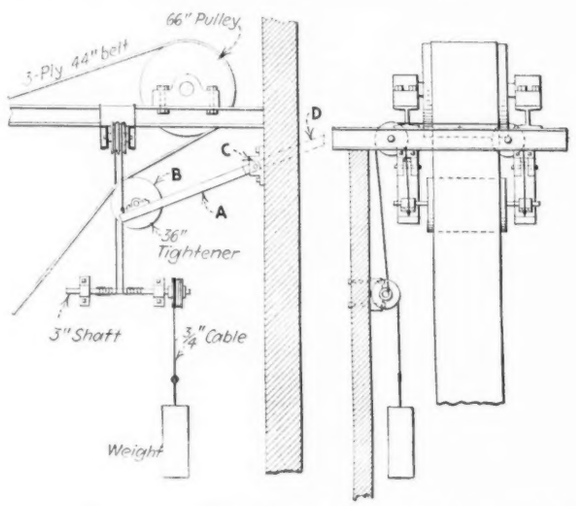
These duties and many others involve upon the commission very important functions which must be carefully carried out if public interest in our water-power resources is to be properly protected. The importance of this work warrants more liberal consideration on the part of Congress, especially since that part of the license fees collected to date for administration of the water-power act, has considerably more than paid all the expenses of the commission, including personnel loaned it by other departments.

Practical Ideas From Practical Men

Arranging a Belt Tightener in a Limited Space

It recently became necessary, when installing two new boilers in our plant, to make some changes in a belt drive, as the weight from the tighteners, which hung on the top of the old boiler, had to be removed to make room for the new boilers. As the space was limited in the engine room, I devised the apparatus shown in the accompanying illustration, and it worked satisfactorily.

The original tightener consisted of two arms *A* on which was mounted the pulley *B*. The arms were pivoted at *C* and had an extension through the wall,



Arrangement of cable and sheaves used in making the belt tightener

as shown by the dotted lines *D*, to which was attached a weight to give the proper tension on the belt.

The tightener pulley and frame weighed approximately one ton, and with a direct pull it would have required an excessive weight on each cable, whereas, the arrangement shown gives a five-to-one purchase and lessens the weight considerably. In one of the cables there is a turnbuckle to raise or lower one side of the tightener to shift the belt. GEORGE W. JACOBS.

Duluth, Minn.

When Orders Invite Co-operation

Most engineers whose power plants are in good operating condition and running efficiently need give few orders to subordinates. As a rule, it is understood what is required of a chief's assistants, and whenever an order must be given, it is done as unobtrusively as possible. A chief engineer commands greatest respect when he confines his orders to such as are absolutely necessary, never as an excuse to show his authority. And then he does well to consider the individual to whom the command is given.

I knew of one chief engineer who worded his orders to suit the subordinate for whom they were intended. He would phrase a command in such a way that it would be of special appeal to that man. Each individual possesses a different temperament, and orders should not be given indiscriminately, without regard for the temperament of the man to whom they are given.

There are men who really wish to be ordered around, they say they are getting paid for doing things. There are also sensitive individuals whose feelings are easily strained. Many a valuable engineer has been lost to the plant because the chief did not consider these feelings. Co-operation is most easily invited when individualizing the orders. Although one man performs his duties the more certainly when given a direct command another will react more speedily and happily when an order is given more or less indirectly. The discerning chief engineer knows just whom to give such an order, and often it is carried out more promptly than is expected or otherwise would be the case. The engineer should see to it that an order fits the individual. F. V. FAULHABER.

Brooklyn, N. Y.

Reconnecting an Induction Motor from Change in Voltage and Speed

There are four conditions in an alternating-current circuit for which it may be necessary to change an induction-motor winding. These are voltage, speed, frequency and the number of phases. To these may be added a combination of two or more of the individual changes. Sometimes these changes can be taken care of by regrouping the old winding, but other conditions will require rewinding the coil for a new number of turns with a different size of wire. In this article it will be shown how the winding in a 10-hp. 220-volt 60-cycle three-phase 1,800-r.p.m. squirrel-cage induction motor was changed for operation on 440 volts 60 cycles, at 1,200 revolutions per minute.

The motor had 72 slots and 72 coils connected in a 4-pole single series-star winding as in Fig. 1. The coils were placed in slots 1 and 18, and each coil was wound with 6 turns of 3 No. 15 double-cotton-covered wire in parallel.

A winding connected single series-star, as in Fig. 1, will be good for the maximum voltage that the winding can be grouped for, therefore if the motor is to operate on double voltage, there is only one way of meeting the situation, namely, make up a new set of coils having double the number of turns, using wire of one-half the original cross-sectional area. In this machine the coils were wound with 6 turns of No. 15 wire, for operation on 220 volts. To make them good for operation or double voltage, or 440, they should be rewound with 12 turns of No. 18 wire and connected as was the original winding.

As the speed of the motor is to be changed, this must also be taken into consideration in the new winding. The speed of an induction motor is determined by the number of poles and the frequency of the circuit. Where the speed and frequency are known, the number of poles may be found by the formula $P = \frac{120F}{S}$, where P equals the number of poles, F the frequency in cycles per second and S the speed. For 60 cycles and 1,800 r.p.m., the number of poles $P = \frac{120 \times 60}{1,800} = 4$. At 1,200 r.p.m. and 60 cycles, the number of poles $P = \frac{120 \times 60}{1,200} = 6$. Therefore to change the winding for 1,200 r.p.m. operation, it will have to be grouped for 6 poles. A change in speed of the motor is the equivalent to a change in voltage. If the winding has 12 turns per coil at 1,800 r.p.m. and 440 volts, it will require $\frac{12 \times 1,800}{1,200} = 18$ turns per coil to operate satisfactorily at 1,200 r.p.m. and 440 volts. As the number of turns in series has been increased three times, the cross-sectional area should be reduced to one-third of the original. The original coils were wound with 6 turns of three No. 15 wires in parallel, which gives three single conductor coils of 6 turns grouped in one coil. Connecting the three in series would give 18 turns in series of one-third the original cross-sectional area, which meets the requirements of the new winding.

Fig. 1—Connection diagram for a 4-pole three-phase single series-star winding

Changing the number of poles in the winding also changes the pitch of the coils, and this must be considered in the new winding. Full pitch for the original winding is, number of slots divided by the number of poles, or $72 \div 4 = 18$ slots; that is, if one side of the coil is in slot No. 1, the other side would be in slot No. 19. The coils were wound in slots 1 and 18, a spread of 17 slots, or one slot under full pitch. This change in the pitch of the winding is so small that it may be neglected in calculating the number of turns per coil.

With the new winding, full pitch is $72 \div 6 = 12$ slots, so that if one side of a coil is in slot No. 1 the other side will be in slot No. 13. This shows that if the 4-pole winding were regrouped for 6 poles, the coils would be spread 5 slots over full pitch. To obtain approximately the same percentage of full pitch for the reconnected winding as for the original connection, the coils should be spread in slots 1 and 12, or one slot under full pitch. The same effect can be obtained by spreading the coils of one slot over full pitch, as a throw over full pitch has the same effect as a throw of less than full pitch. Reducing the pitch causes the ends of the coils to extend out farther from the core and may interfere with putting the end bells in place.

It was at first decided to lift the top sides of the coils from the slots and reduce their throw to 1 and 14, which is one slot over full pitch and would be the equivalent of one slot under full pitch. When this was tried, it was apparent that the clearance in the end bells would be quite close, and it was decided to compromise and wind the coils in slots 1 and 15. This was two slots over full pitch, which was found to work out satisfactorily. The diagram of the 6-pole winding is shown in Fig. 2.

Fig. 2—Connection diagram for a 6-pole three-phase single series-star winding

Since the speed of the motor has been reduced, the horsepower will be reduced approximately as the speed. At 1,800 r.p.m. the rating was 10 hp. At 1,200 r.p.m. the rating becomes $(10 \times 1,200) \div 1,800 = 6\frac{2}{3}$ hp. Allowing 1,000 volt-amperes per horsepower, which is a fair value for the average motor, the current taken by the 10-hp. 220-volt motor equals $\frac{1,000 \times 10}{220 \times 1.732} = 26$ amperes. For the $6\frac{2}{3}$-hp. 440-volt motor the current equals $\frac{1,000 \times 6\frac{2}{3}}{440 \times 1.732} = 8.7$ amperes, which is about one-third that for the 220-volt machine.

Cleveland, Ohio. P. W. SAWYER.

Comments from Readers

Some Factors Overlooked When Changing from Generated to Purchased Power

An important factor in the question of generated versus purchased power, though often overlooked, is the condition of the existing boiler plant and its suitability for higher-pressure operation. The fact that a new manufacturing plant under construction omits power-generating equipment is no criterion of proper solution of the power problem of the older plants engaged in manufacturing the same line of goods. But unfortunately there will be one or more men serving on the board of directors of both the new plant and an older one, and in view of the savings made by purchasing power in one instance, vigorously advocate the same policy for all plants under this particular ownership. Several local instances can be cited.

One plant is purchasing all its power at an annual cost of over $400,000 and has a high-pressure boiler plant in good condition, capable of operation at 200-lb. pressure, underfeed stokers and complete coal handling and storage equipment, installed at a cost of nearly half a million dollars. Owing to the nature of the product, elaborate pumping machinery and air compressors are in operation twenty-four hours a day, necessitating an engineer and oiler on each watch, and the demand for process steam exists at all times. Every chief engineer who has been there in the last ten years has submitted estimates of the cost of installing a back-pressure turbine, which would show a saving of $50,000 annually, with only $50,000 or less for installation of a unit large enough to handle the average process steam flow. Such a unit would have a 75 per cent load factor, and the only costs would be the capital charges and slight extra fuel consumption due to the heat extracted during expansion of the steam from 200 lb. to the process pressure of 70 lb.

But they all received the same answer—that isolated power plants are a relic of the past and that the back-pressure turbine would use from 80 to 100 lb. of steam per kilowatt-hour while the power company's units need but 10.5 lb. The fact that the steam flow averaged 100,000 lb. an hour anyway did not have any weight, nor did the argument that an average load of 1,000 kw. could be carried on the process steam flow receive any consideration. Had it been necessary to renew or revamp the boiler plant, at a cost of $100,000 to $200,000, the decision not to generate power could be justified, but it is hard to understand why an expenditure of nearly $500,000 should be approved in order to generate steam efficiently and then allow it to be used in such a wasteful fashion, refusing to spend the remaining $50,000 for a power unit.

Another plant had no process steam load, but the minimum heating load was 15,000 lb. an hour for six months a year. No generating unit had ever been used, but they had high-pressure water-tube boilers. After operating five years with an overfeed type of stoker, $25,000 was spent for new underfeed stokers. All boilers were equipped with new stokers against the engineer's advice. His stand was that half the boilers could handle the minimum steam load of 15,000 lb., and the maximum load of 30,000 lb. existed only two months of a year. He recommended cutting the stoker investment in half, thereby generating two-thirds the total steam flow, with the improved boilers. He proposed the installation of a 350-kw. second-hand generating unit, consisting of a vertical high-speed engine. To overcome the former objections of lack of room, he pointed out a space in the machine shop that was ample for the installation of the power unit. As most of his work was in the machine shop and he had a large repair crew, there would be no additional labor cost involved in the operation of the engine. It would save $10,000 a year, generating 1,000,000 kw.-hr. during the heating season at an initial cost of $7,500, whereas the same sum invested in stokers saved only $3,000 a year.

In each case the capital charges on the boiler plant had to be carried, regardless of whether power was generated or not. Also the plan of generating part of the power insured at least a partial power supply in case of outside power interruption.

Springfield, Mass. A. F. SHEEHAN.

Changes Made to Boiler Settings to Improve Operating Conditions

I was much interested in the article in the Oct. 26 issue entitled "Changes Made to Boiler Settings to Improve Operating Conditions," because I am constantly in touch with work of this kind.

It is somewhat difficult to understand why better results were obtained with the setting shown in Fig. 2, and one can only assume that the trouble was due to some other cause than that stated.

Take the setting illustrated in Fig. 1. However poor the design, one could hardly expect an exit temperature of 1,200 deg., provided the gases pass through the proper circuit on their way to the chimney. Instead of bad design it would point to short-circuiting of gases from the combustion chamber through the baffling to the boiler exit.

Any defect in the baffling could be readily found by obtaining the relative draft pressures in the various passes of the boiler, which would show immediately where any obstruction occurred or undue short-circuiting of the boiler gases took place.

The setting shown in Fig. 2, which has given better results, cannot in my opinion be considered as an improvement over Fig. 1 as far as design is concerned, and would appear contrary to all practice with respect to combustion chamber areas.

In Fig. 1 the gases leaving the stoker at the end of the arch, where they will be at their highest temperature and volume, have a dimension of 5 ft. 8 in., by width of the setting through which they have to pass, from which point to their entry into the first pass they are considerably reduced in temperature; but in the

setting shown in Fig. 2, the gases also at their highest temperature and volume, leave the arch in a restricted area—that is, 3 ft. 10 in., by the width of the boiler—and immediately pass into a still further restricted area only 1 ft. 6 in. wide, up to a point where they enter the first pass.

The effect of this, I feel sure, could have only one result; that is, to reduce still further the available draft in the combustion chamber proper and consider-

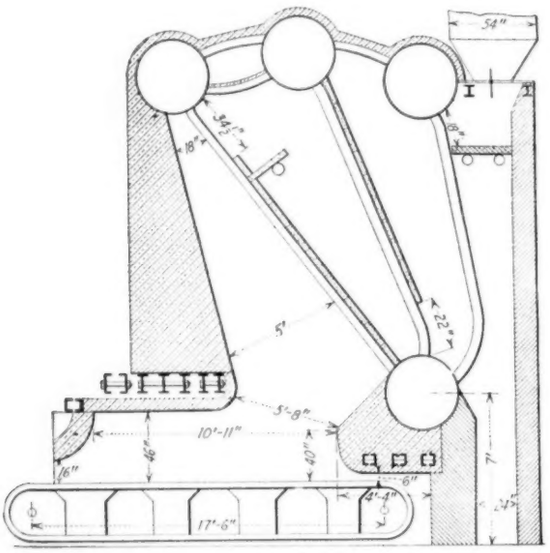


Fig. 1—Original boiler setting

ably reduce the rate at which it would be possible to burn fuel, and at the same time tend to increase rather than diminish the exit-gas temperatures.

If, in the first instance, Mr. Smith had measured the draft in each pass, and combustion chamber, and studied the readings, he would have decided to alter the dimensions of the openings to each of the passes, as he has done in Fig. 2, and thereby would have saved the greater part of his costs of reconstruction and at the same time obtained improved results in both steaming and efficiency.

J. T. RUDDOCK.

Bolton, England.

The discussion by J. D. Carr in the Nov. 23 issue on this subject was no doubt prompted by the fact that the fuel burned in the region of Scranton, where Mr. Smith is located, is principally anthracite buckwheat, and Mr. Carr's unfamiliarity with the burning characterestics of this coal. No mention is made of the kind of coal used by either contributor, but in my opinion the setting shown is suitable only for burning buckwheat.

In burning high-volatile coals or oil, the fuels used in California, it is easy to maintain a high furnace temperature, and if enough volume is allowed, complete combustion takes place. With these conditions every effort is made to absorb the radiant heat of the fire and to expose as much heating surface as possible to the direct rays of the furnace. This gives a low exit gas temperature at the damper due to the high absorption of radiant heat. For soft coal the setting as first built would serve with a few changes.

In burning buckwheat on chain-grate stokers with forced draft, several entirely different conditions must be met. First, anthracite is slow to ignite and the ignition does not penetrate rapidly as in soft coal. Less anthracite can be burned per square foot of grate surface. The fire is usually kept at three to four inches in depth on the grate, and a slight change in draft may blow holes through it. The ash content is high and unless the end of the grate is covered by an arch, much unburned carbon is lost in the ash.

The gases from the front section of the grate are deficient in oxygen, while the thinner fire and holes at the back give excess air over the back portion of the grate. These streams of gas must be mixed and allowed to burn before reaching the boiler tubes.

With the original setting a low furnace temperature and slow ignition would result. The gases were not mixed or burned before reaching the tubes, and secondary combustion probably took place at the top of the first pass, thus raising the exit temperature to 1,200 deg. Dirty tubes also probably played a part, as it is customary around the mines to do less boiler cleaning owing to the low cost of coal, the high cost of labor and the great length of time necessary to cool off the long and complicated arches.

Therefore, while the setting shown in Fig. 2 may appear incorrect to soft-coal operators, it is an improvement for the burning of anthracite buckwheat. Better combustion would result if the stoker were moved far-

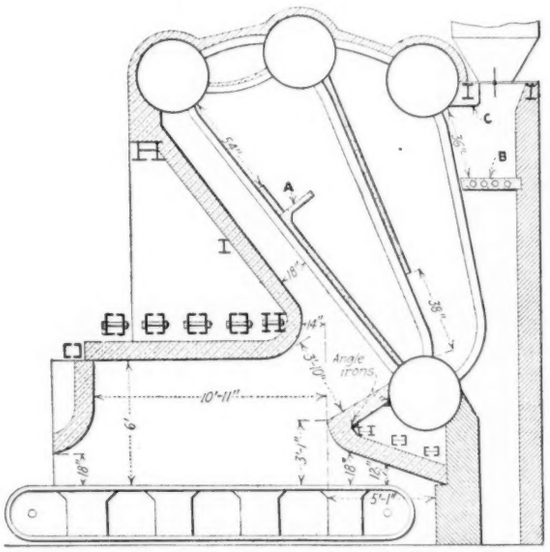


Fig. 2—Changes made in arches and baffles

ther under the boiler, thus shortening the front and lengthening the rear arch.

The real point is that each fuel must be treated differently and changes in settings should not be made unless the conditions to be met are fully understood.

Nanticoke, Pa. J. KEENAN.

THE TOTAL EXPENDITURES OF THE STATE UNIVERSITIES and colleges during the college year 1924-25 was $154,584,675, divided as follows: Salaries and wages, 51 per cent; materials and supplies, 23 per cent; buildings and land, 14 per cent; equipment, 4 per cent; trust funds, 2 per cent; not detailed in reports, 6 per cent. An analysis of the detailed figures reveals that the University of California spent more for salaries and wages than any other state college or university—over $5,000,000 in a single year.

News in the Field of Power

Heating and Ventilating Men Plan Record Gathering

A diversified program of important technical papers will feature the coming thirty-third annual meeting of the American Society of Heating and Ventilating Engineers, which will be held at the Hotel Statler, St. Louis, Mo., Dec. 25 to 28.

Under the direction of E. B. Langenberg, president of the local chapter, the St. Louis committee arranged and submitted to the council a tentative program which met with approval. In order that detailed reports of committee activities for the year can be presented to the membership, the entire day of Tuesday, Jan. 25, will be devoted to committee meetings. The arrangement provides members with sufficient time for conference prior to the opening session the morning of Wednesday, Jan. 26, when W. H. Driscoll, president, will greet the members.

PAPERS AND RESEARCH SESSION

Further studies of the "Heating Effect of Radiators" by Dr. Charles W. Brabbée will be given at the opening session. A personal experience telling about the value of cork for insulating a residence has been prepared by Lee Nusbaum and offers some comparative cost data collected during several heating seasons. The subject of air filters is one of outstanding importance and the "Design and Application of Oil Coated Filters" will be discussed by H. C. Murphy, while a "Simple Method for Testing Air Filters" will be given by Tufty and Mathis.

An entire session is to be devoted to research and the work of various technical advisory committees will be reported by the chairman. Several laboratory presentations will also be made.

Chairman H. P. Gant of the committee on research, will review the year's program and the progress of the work at the laboratory in Pittsburgh will be given by Director F. C. Houghten.

Indications that valuable data will be brought out at the Schoolhouse Ventilation Session are apparent, as the work of the committee to cooperate with the Rochester School Board will tell of the progress of this project, and several papers by leading men in the architectural and school administration field will give the members some practical observations on the schoolhouse heating and ventilating problems.

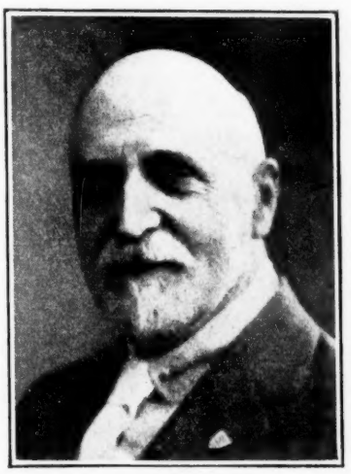
Senator Harrison Predicts Muscle Shoals Passage

Disposition of the Government-owned power and nitrogen project at Muscle Shoals on the Tennessee River in Alabama will be worked out in the present session of Congress, according to Senator Harrison, democrat, of Mississippi.

Senator Harrison stated orally, Dec. 4, that he looked for Congress to "dispose of the Muscle Shoals problem, pass tax legislation, and the appropriation bills, and consider agricultural relief legislation."

Engineers Acclaim Alex Dow at Testimonial Dinner

Commemorating the distinguished career of Alex Dow, president of the Detroit Edison Co. and one of the foremost leaders in the electrical field, a complimentary dinner was tendered him jointly by the Detroit Engineering Society, the Detroit Section of the American Society of Civil Engineers, the Detroit Section of the American Society of Mechanical Engineers, and the Detroit-Ann Arbor Section of the American Institute of Electrical Engineers at the Hotel Book-Cadillac, Detroit, Dec. 4.



Alex Dow

Mr. Dow took charge of the Edison Illuminating Company of Detroit as vice-president and general manager on July, 1896, more than thirty years ago. In December, 1912, he was elected president of the Detroit Edison Co., holding the title and full duties of general manager until February, 1923. As president and chief executive, Mr. Dow still continues to direct the larger affairs of the company, maintaining close touch with engineering progress.

ACTIVE IN ENGINEERING AFFAIRS

Mr. Dow visited England last spring accompanied by James W. Parker, chief engineer of the company, for the renewal of personal acquaintanceships and for the study of power-plant engineering practice abroad.

Mr. Dow's contributions to engineering progress, his relations to the University of Michigan, and his services to city and state formed the general subject of eight addresses.

Welcome was offered by the Hon. John W. Smith, mayor of Detroit. Gardner S. Williams, charter member and first secretary of the Detroit Engineering Society, tendered toastmaster's introduction, which was followed by a poem "Alex Dow" by Granger Whitney. In his address Charles W. Stone, manager of the central station department of the General Electric Co., took up Mr. Dow's contributions to electrical engineering, while Mortimer E. Cooley, dean of the College of Engineering and Architecture, University of Michigan, spoke of the academic influence of Mr. Dow in "Relations to the University of Michigan."

His standing with the financial interests was the topic of Edwin M. Bulkley, vice-president of Spencer Trask & Co., New York City. Hon. John C. Lodge, president of the Common Council, City of Detroit, closed the speeches with his address "Services to the City of Detroit."

"Bureau of Standards Greatest of Laboratories"—Hoover

At a dinner commemorating the twenty-fifth anniversary of the establishment of the Bureau of Standards, held on Dec. 4 in the New Willard Hotel in Washington, D. C., Herbert Hoover, Secretary of Commerce, spoke in praise of the Bureau, which, he said, today represents the greatest of the world's physical laboratories, not only covering its special field of the development of precision in standards, but extending its activities and efforts into the wider field of scientific research.

Among those following Mr. Hoover with addresses were Dr. Frank A. Wolff, of the Bureau of Standards, who sketched the steps leading up to the establishment of the Bureau, together with a prediction of the Bureau's future; David Lawrence, president of the *United States Daily*, speaking on the support and cooperation of that paper in matters undertaken by the Bureau.

AGRICULTURAL SESSION URGED

Robert B. Howell, senator from Nebraska, outlined the accomplishments which could be realized in the agricultural betterment of the country if such a department of the Bureau were established.

Former Secretary of Commerce, George B. Cortelyou read the concluding paragraph of the first annual report summarizing the aims of its organizers and what they hoped for the future.

Addresses were also tendered by William B. Oliver, representative from Alabama, and Dr. S. W. Statton, former director of the National Bureau of Standards.

Governor Smith Warns Board of Salmon River Project

Governor Smith sent a letter to members of the Water Control Commission Dec. 6, urging them to deny the pending application for a river regulating district in the Salmon River.

He declares that before any action is taken on the application the Conservation law should be amended, and that while power companies would gain about $250,000 a year the State would receive only $720 a year.

"The setting up of a river regulating district on the Salmon River is in effect to bring about what was sought to be done by Section 7 of Article 7 of the Constitution," said the letter. "This amendment the people overwhelmingly defeated in 1923." The letter, in part, as published by the *New York Times*, follows:

"There is pending before you an application to set up under the provisions of the Conservation law a river regulating district on the Salmon River. The Constitution of the State provides that reservoirs may be constructed, owned and controlled by the State for municipal water supply, for the canals of the State and to regulate the flow of streams.

"In 1923 there was submitted to the people of the State an amendment to the Constitution that would permit the Legislature to provide by general laws for the use of such lands for the development of water power. The proposed amendment was overwhelmingly defeated by the people at the polls.

DEPLORES LAW RETURN

"River regulating districts, under the conservation low, may be set up for the protection of the public health where the streams or rivers have become polluted and for the protection of life and property because of flood. I am unable to understand that either of these two reasons has been set forth by sufficient testimony to warrant the setting up of a river regulating district on the Salmon River, and I feel confident that private corporations contemplate the use of the water to provide electrical energy. A similar effort was made to secure a river regulating district on the Racquette River, which was happily prevented following the disclosure of its true purpose.

"Before any action is taken to set up any river regulating district the conservation law should be amended, even assuming that there might exist one of the two reasons given for the establishment of the district. The amendment to the conservation law should change that part of it written into the law in 1921, which permits only a ridiculously low return to the State for the value of the water power given to the private owners."

Says Laws Prevent Oil Saving by Banning Combinations

The oil industry faces a paradox, holds Thomas A. O'Donnell of Los Angeles, attending the annual convention of the American Petroleum Institute which began Dec. 7. The only practical plan for conservation of the nation's oil resources would violate the law against combinations and agreements, he said, and he never had seen "any effective national plan presented except agreements in writing between the producers." He believes any attempts to legalize such agreements would be unwise.

Seeks Authority To Merge Six New York Utilities

Petition has been made to the Public Service Commission for authority to consolidate the Central Hudson Gas & Electric Co., of Poughkeepsie, the Dutchess Light, Heat & Power Co., of Rhinebeck, the United Hudson Electric Corp., of Poughkeepsie, the Kingston, N. Y. Gas & Electric Co., the Ulster Electric Light & Power Co., of Saugerties, and the Upper Hudson Electric & Railroad Co., of Catskill, into a new corporation, to be called the Central Hudson Gas & Electric Corp.

The six companies which are to be consolidated into the new company, as proposed in the petition, supply gas and electricity for light, heat and power in various cities, villages and towns in Orange, Ulster, Dutchess, Columbia, Greene and Albany counties. A public hearing on the petition was held at the New York office of the Commission, 120 Broadway, Dec. 3.

International Trade Terms Show Marked Increase

Recognizing that the language of trade must have an exact meaning, the International Chamber of Commerce is preparing a revision and enlargement of its compendium of international trade terms. The trade parlace of 24 countries, instead of the 13 included in the original publication, will be defined in the new book.

Obituary

W. A. Kreider, who for over thirty years was manager of the Chicago branch office of the Ball Engine Co., died at his residence in Chicago on Nov. 23. Over a year ago he had resigned his duties owing to failing health, and the end came suddenly. The burial took place at Monroeville, Ohio, the home of his mother. Mr. Kreider was a well-known authority in the steam-engine field, and his passing will be regretted by his many engineering friends.

Charles S. Cook, widely known in electrical manufacturing as vice-president and treasurer of the Kaestner & Hecht Elevator Co. and as formerly associated with the Westinghouse Electric & Manufacturing Co., and the Duquesne Light Co., died recently. Identified with the electrical industry since 1887, Mr. Cook had been a conspicuous figure in the electric light and power field, street and urban railway development, as well as the electrification of steam railways. He entered the employ of the Westinghouse company in 1887, and soon after became an erecting engineer. Later, he was sent to the Chicago office and while there received an appointment as sales engineer. In 1892 he laid out and sold the first long-distance transmission system installed in the United States. In the same year Mr. Cook laid out the power system for the World's Columbian Exposition at Chicago. In 1895 he was transferred to Pittsburgh to take up the application of electrical apparatus to steel mills. He was made manager of the Westinghouse Pittsburgh office in 1899 and five years later became manager of the Westinghouse railway and lighting department at East Pittsburgh. This position he held until 1917, when he resigned to become general manager of the Duquesne Light Co. In 1924 he affiliated himself with the Kaestner & Hecht Co., as vice-president and treasurer, with headquarters in Chicago.

Personal Mention

Harold D. Gregory has joined the patent department of the American Brown Boveri Electric Corp. Mr. Gregory is a graduate engineer from the Stevens Institute.

Alfred E. Waller, chief engineer of the Ward Leonard Electric Co., has been appointed managing director of the National Electrical Manufacturers Association effective on the thirteenth of December.

Gage R. Cooper, formerly with the Houghton County Electric Light Co. at Houghton, Mich., has joined the power division of Stone & Webster, Inc., as assistant engineer on meter testing for operating companies.

F. C. Evans, assistant professor of heat power engineering at Cornell University, co-operated with the editorial staff of *Power* at the A.S.R.E. and petroleum sessions of the Power Show, New York City, Dec. 6-11.

W. F. Barrett's election to a vice-presidency was announced by the Union Carbide & Carbon Corp. following a meeting of the board of directors of the corporation at New York on Nov. 23. Mr. Barrett began his association with the subsidiary companies of the corporation in August, 1913, when he became works manager and chief engineer of the Linde Air Products Co.

Business Notes

The Westinghouse Electric & Manufacturing Co. has appointed E. R. Stone manager of the stoker sales department, to succeed G. A. Sacchi, who died recently. Mr. Stone had been affiliated with the Westinghouse organization practically from boyhood.

The Wickes Boiler Co. has appointed Henry E. Aldrich general manager with headquarters at Saginaw, Mich., and J. Robert Fortune as general sales

manager with headquarters at General Motors Building, Detroit, Mich., where the Detroit district sales office will be located Jan. 1.

The Union Carbide & Carbon Corp. announce the election of G. W. Mead to membership on the board of directors as an important action of the board meeting on November 23. Mr. Mead has been identified with subsidiaries of the corporation since 1906, when he was elected the first secretary of the Union Carbide Co.

Trade Catalogs

Machine Regulation of Pulverized Coal Fired Boilers—The Smoot Engineering Corp., 136 Liberty St., New York City, has issued recently Bulletin No. 31 on Smoot control with practical suggestions for starting and operating pulverized-coal furnaces. Designed for the use of chief engineers and operating men of large stations, the issue is replete with specifications for combustion control and installation charts.

Pulverized Coal Equipment—The Fuller-Lehigh Co., Fullerton, Pa., in Bulletin 901 lists and describes the Fuller drier, Randolph vertical drier, Fuller pulverizer mills of screen and air separator types, Lehigh pulverizer mill, Fuller-Bonnott unit mill, Fuller impact unit pulverizer mill, Fuller-Kenyon conveying system, the Fuller and the Bailey pulverizer coal feeders and meters, and the Bailey-Tenney burner.

Electric Operation of Valves—The Coffin Valve Co., Neponset, Mass., in Section 4B of the general catalog of Coffin products, describes the Kelty motor-drive unit, under the headings of motor operation of valves, application of the Kelty motor-drive unit to valve operation, design, electrical equipment, advantages claimed for the Kelty motor-drive unit and adjustments. Numerous diagrams and figures serve to give ample illustration to this section of the catalog, which is divided into seven sections, each of which can be obtained in pamphlet form.

Nickel Steel — The International Nickel Co., 67 Wall St., New York City, has published Bulletin No. 9, "Physical Properties of Nickel and Nickel Chromium Steels." Compiled by the development and research department, the bulletin is in perforated form for binding, in which curves showing the average values of tensile strength elastic limit, reduction of area, elongation and Brinell hardness at various drawing temperatures are given for the S.A.E. standard nickel and nickel chromium steels. Tables of the maximum and minimum values of these same properties, reported by various authorities, are also given, together with causes of variations and notes on the use of the data in design.

Steam-Jet Conveyors—The Hahn Engineering Co., Philadelphia. The Hahn steam-jet conveyor for ashes, slag, soot, coke and other abrasive materials is considered as to consumption of steam, maintenance, elimination of dust and noise, and the use of compressed air instead of steam in a brief bulletin.

Control System for Direct-Current Motors—The General Electric Co., Schenectady, N. Y., describes and illustrates with figures and charts the MT control system for direct-current motors in issue GEA-451.

Coming Conventions

American Association for the Advancement of Science. Annual meeting at Philadelphia, Dec. 27-Jan. 1; Burton Livingston, Secretary, Smithsonian Institution Bldg., Washington, D. C.

American Engineering Council. Annual meeting at Washington, D. C., Jan. 13-15. L. W. Wallace, 24 Jackson Place, Washington, D. C.

American Institute of Electrical Engineers. Winter convention at New York City, Feb. 7-10; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Society of Heating and Ventilating Engineers. Annual meeting at St. Louis, Mo., Jan. 25-28; A. V. Hutchinson, secretary, 29 West 39th St., New York City.

Chicago Power Show, at Chicago, Feb. 15-19. G. E. Pfisterer, managing director, 53 West Jackson Blvd., Chicago.

Engineering Institute of Canada. Richard John Durley, secretary, 176 Mansfield St., Montreal, Que. The forty-first annual general and general professional meeting will be held at Montreal on Thursday, Jan. 27, and will be adjourned to reconvene at Quebec City at the Chateau Frontenac Hotel Feb. 15, continuing on the two succeeding days.

National Association of Stationary Engineers. New England States convention at Portland, Me., June 17-18. Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Annual convention at Atlantic City, week beginning June 6.

National Marine Engineers' Beneficial Association. Fifty-second annual convention at the Hotel Franklin Square, Washington, D. C., Feb. 14. Albert L. Jones, secretary-treasurer.

Pneumatic Collecting and Conveying Machines—The B. F. Sturtevant Co., Hyde Park, Boston, Mass. Part one of Catalog 291 is devoted to the description of apparatus used in dust collecting and pneumatic conveying systems. It describes the advantages of pneumatic systems, conveying of fibrous materials, dust collectors, dust collecting from miscellaneous materials, such as sand-blast machines, shoe machinery, tumbling barrels, grinding and polishing wheels, and blowpipe and wood refuse handling. Part 2 includes data covering design and application of collecting systems, area and weight of round galvanized pipe and area of circles, the engineering method and design used in dust-covering systems, tables for friction loss in pipes, methods of determining size of fan and pipes, size of connections for grinding, polishing wheels, and woodworking machinery, slow speed fan performance tables and other miscellaneous tables and engineering data. This engineering bulletin is available for free distribution.

Flue-Gas Thermometers—The Foxboro Co., Foxboro, Mass., has issued Bulletin 147 on Foxboro flue-gas thermometers. The new pivoted pen arm movement used on all Foxboro multiple-pen recorders makes the combination of related records with that of flue gas on one chart simple and practical for comparison. The pens move on the same fixed center of rotation. The three records given by the three-pen long-distance recording thermometer tell at a glance the efficiency of the economizer.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Nov. 29 1926
Pool 1	New York	$3.75@$4.25
Smokeless	Boston	4.00
Clearfield	Boston	2.50@ 3.00
Somerset	Boston	2.75@ 3.25
Kanawha	Columbus	2.25@ 2.75
Hocking	Columbus	2.00@ 2.50
Pittsburgh	Pittsburgh	2.35@ 2.50
Pittsburgh gas slack	Pittsburgh	2.00@ 2.10
Franklin, Ill.	Chicago	2.75@ 3.00
Central, Ill.	Chicago	2.50@ 2.75
Ind. 4th Vein	Chicago	2.50@ 2.75
West Ky.	Louisville	1.25@ 2.00
S. E. Ky.	Louisville	2.10@ 2.75
Big Seam	Birmingham	2.00@ 2.25
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.25@ 3.50
Buckwheat No. 1	Philadelphia	2.40@ 3.00
Birdseye	New York	1.25@ 2.00

FUEL OIL

New York—Dec. 8, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

St. Louis — Dec. 2, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 6c. per gal.; 38@40 deg., 7.37½c. per gal.

Pittsburgh—Nov. 30, f.o.b. local refinery; 30@34 deg., fuel oil, 6½c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Philadelphia—Dec. 1, 27@30 deg., $2.52@$2.58 per bbl.; 13@19 deg., $1.725@$1.785 per bbl.

Cincinnati — Nov. 29, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Nov. 30, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.35 per bbl.; 26@30 deg., $1.45; 30@32 deg., $1.65.

Boston—Dec. 6, tank-car lots f.o.b 12@14 deg. Baumé, 4¾c. per gal.; 28@32 deg., 6c. per gal.

Dallas—Nov. 9, f.o.b. local refinery 26@30 deg., $1.70 per bbl.

New Plant Construction

Ark., Morrillton—Morrillton Cotton Mills, c/o E. T. Curry, Morris & Co., Groveville, N. J., awarded contract for the construction of a textile mill including boiler house, etc. here to Monolith Builders, Little Rock, Ark. Individual motor driven machinery will be installed.

Calif., Long Beach—Seaside Investment Co., plans the construction of an 8 story addition to hotel including steam heating system, elevators, etc. on Long Beach St. Estimated cost $1,500,000. Austin & Ashley, Chamber of Commerce Bldg., Los Angeles, are architects.

Calif., Los Angeles—City Water & Power Commission, will receive bids until Dec. 17 for oil circuit breakers. Estimated cost $30,000.

Calif., Los Angeles—Hollywood Olympic Holding Co., c/o Walker & Eisen, Western Pacific Bldg., Archt., awarded contract for the construction of a 9 story club building at Franklin and Highland Aves. to Bard & Co., Pacific National Bank Bldg. Estimated cost $650,000. Steam heating and refrigeration system, elevators, etc. will be installed.

Calif., Sacramento—City, H. G. Denton, Clk., plans to purchase one vacuum pump for Engineering Department. A. J. Wagner, is engineer.

Calif., South San Francisco—George Morrill Co., 130 Fremont St., San Francisco, awarded contract for the construction of a factory including boiler house, etc. on Linden St. here, to P. J. Walker Co., Sharon Bldg., San Francisco.

Conn., Hartford—Basch & Blumenthal, 130 Market St., awarded contract for the construction of a produce warehouse to G. Cudemo & S. N. E. Construction Co., Inc., 68 Temple St. Estimated cost $150,000. Extensive refrigeration system will be installed.

Ill., Chicago—Syndicate c/o O. J. Friedman, 11 South La Salle St., awarded contract for the construction of a 34 story office and stores building at 333 North Michigan Ave. to Hegeman-Harris Co., 431 North Michigan Ave. Estimated cost $3,000,000.

Ill., Chicago—Western Electric Co., South 48th Ave. and West 22nd St., awarded contract for remodeling and reconstructing 16 buildings, at Hawthorne Works, to Turner Construction Co., 6 North Michigan Ave. Estimated cost $2,500,000.

Ill., Olney—City will receive bids until Jan. 4 for the construction of a complete waterworks and distribution system including pumping equipment, filtration plant, etc. Estimated cost $175,000. Edward Flad & Co., 920 Chemical Bldg., St. Louis, Mo., are engineers.

Ill., Richmond—City voted $12,000 bonds for waterworks improvements including well, pumping equipment, tank on tower, etc. Wells Engineering Co., Geneva, Ill., is engineer.

Ill., Springfield — Concordia Theological Seminary, H. A. Klein, Pres., 812 North 12th St., plans the construction of a group of 5 buildings including boiler house. Estimated cost $750,000. Helmle & Hemle, First National Bank Bldg., are architects and engineers.

Ia., Davenport—Weary & Alford, 1923 Calumet Ave., Chicago, Ill., Archts., will receive bids about Jan. 1 for the construction of a 13 story bank and office building at 3rd and Main Sts. here, for American-Commercial & Savings Bank, 230 Main St. Estimated cost $2,000,000. Clausen, Kruse & Klein, Kahl Bldg., are associate architects.

Ia., Grinnell—City, H. B. Lowery, Clk., will readvertise for bids for improvements to sewage disposal plant including one centrifugal pump with gasoline or electric motor, etc. R. B. Slippy Engineering Corp., 405 Lafayette Bldg., Waterloo, is engineer Former bids rejected.

La., Cedar Grove — Independent Ice & Refrigerator Co., T. T. Harris, Pres., Abilene, Tex., awarded contract for the construction of an ice plant at 70th St. and Atkins Ave. to Werner Co. Inc., Shreveport. Estimated cost $11,347.

Md., Baltimore—Mayor and City Council, City Hall, awarded contract for the construction of a 13 story office building at Holliday, Lexington and Guilford Aves. to J. Henry Miller, Inc., Eutaw and Franklin Sts. Estimated cost $1,600,000. Contractor will award all mechanical equipment including heating, ventilating, etc.

Md., Laurel—Bd. of Commissioners, Washington, D. C., will soon award contract for the construction of a power plant for District Training School.

Mass., Cambridge (Boston P. O.)—Middlesex County Commission, will soon award contract for the construction of a boiler house, at 32nd and Thorndike Sts. Estimated cost $175,000. E. C. Brown & Co., 220 Devonshire St., Boston, are engineers.

Mass., Somerville (Boston P. O.)—New England Creamery Products Co., Somerville Ave., is in the market for refrigeration equipment for proposed plant at Somerville Ave. and Fitchburg St.

Mich., Detroit — J. J. Barlum, Barlum Bldg., awarded contract for the construction of a 40 story office building on Cadillac Sq. to Otto Misch Co., 159 East Columbia Ave. Estimated cost $5,000,000. Steam heating equipment, 10 elevators, etc. will be installed.

Mich., Detroit — League of Catholic Women, 1234 Washington Blvd., will soon award contract for the construction of a 6 story office building including steam heating equipment, elevators, etc. on Parsons St. Smith, Hinchman & Grylls, 800 Marquette Bldg., are architects.

Mich., Royal Oak — Washington Stores Co., c/o F. D. Madison, Archt., is having plans prepared for the construction of a theatre and office building including steam heating boiler and equipment at Fourth and Washington Sts. Estimated cost $2,000,000.

Mo., Kansas City—American Ice Co., 205 West 71st St., is having plans prepared for the construction of an ice plant. Estimated cost $40,000. H. Von Unwerth, 705 Finance Bldg., is engineer.

Mo., Rolla—Missouri School of Mines and Metallurgy, is having preliminary plans prepared for the construction of a fuel and power house. Estimated cost $58,000.

Neb., McCook—City, G. F. Moss, Clk., will receive bids until Dec. 20 (extended date) for waterworks improvements including two 600 g.p.m. pumps and motors, etc. Estimated cost $45,000. Bruce & Grupe, 310 Bankers Reserve Bldg., Omaha, are engineers.

N. Y., Long Beach — J. Manowitz, will build a hotel including 3 electric elevators at Broadway and Magnolia Blvd. Estimated cost $750,000. Work will be done by separate contracts under the supervision of H. Hurwit, 41 West 33rd St., Archt.

N. Y., New York—Rose Marie Co. Inc., A. Hammerstein, Pres., 1650 Broadway, will soon receive bids for the construction of a 15 story theatre and office building including 4 electric elevators at 211 West 53rd St. Estimated cost $1,500,000. H. J. Krapp, 1 West 47th St., is architect.

N. Y., Syracuse—Syndicate, W. A. Dyer, Chn., 995 James St., had plans prepared for the construction of a 10 story hospital and nurses' home including all equipment on Irving Ave. Estimated cost $2,500,000. J. Pope, 542 5th Ave. and D. J. Baum, Spuyten Duyvil, Parkway and Waldo Ave., are architects.

O., Cincinnati—Union Central Life Insurance Co., Fourth and Vine Sts., will soon award contract for the construction of an 8 story office building at Third and Vine Sts. Estimated cost $3,000,000. Garber & Woodward, 4 West 7th St., are architects.

O., Cleveland Heights (mail Warrensville)—F. N. Riley & Associates, Hanna Bldg., Cleveland, is having preliminary plans prepared for the construction of a 5 story apartment here. Estimated cost $650,000. J. F. Steffens, Fidelity Mortgage Bldg., Cleveland, is architect.

Pa., Scranton—R. M. Hood, 40 West 40th St., New York, N. Y., Archt., will receive bids until Dec. 21 for the construction of a masonic temple including low pressure steam boilers, water tube boilers, 2 electric elevators, etc. on Washington Ave. here, for Scottish Rite Masonic Order, Scranton, Pa.

R. I., Kingston — Rhode Island State College, plans the construction of addition to power plant. Estimated cost to exceed $40,000.

Tex., Crystal City — Central Power & Light Co., E. B. Neiswanger, Frost Bldg., San Antonio, is in the market for a 400 hp. engine unit for proposed addition to power plant here. Estimated cost $16,000.

Tex., Cuero — T. O. Bushel, has been granted permit by the State Bd. of Water to irrigate 856 acres of land. Water will be used from Guadalupe River. Estimated cost $18,000. Pumping equipment, engine, etc. will be required.

Tex., Houston—Houston Terminal Warehouse & Cold Storage Co., O. H. Baker, 1317 Post Dispatch Bldg., awarded contract for the construction of a 6 story warehouse and cold storage plant to Jesse H. Jones & Co., Bankers Mortgage Bldg. Estimated cost $1,500,000.

Tex., Laredo—A. C. Richter, Laredo and H. C. Wood & Associates, Travis Bldg., San Antonio, will receive bids about Dec. 25 for the construction of a 10 story hotel including 3 elevators, etc. here. Estimated cost $500,000. Kelwood Co., Travis Bldg., San Antonio is architect and engineer.

Tex., Levelland—City plans an election Dec. 22 to vote $50,000 bonds for the construction of a waterworks system including well, pumping equipment, etc. Hawley & Roberts, Box 1115, Lubbock, are engineers.

Tex., Pittsburg—East Texas Public Service Co., Marshall, awarded contract for the construction of a 35 ton ice plant here to L. E. Myers & Co., Athletic Bldg., Dallas. Total estimated cost $70,000. Electrically-driven machinery will be installed.

Tex., San Antonio — Central Power & Light Co., E. B. Neiswanger, Frost Bldg., is having plans prepared for extensions and improvements to power plants at various points in South Texas. Private plans. New and larger engine units will be installed.

Tex., San Antonio—G. A. Duerler Mfg. Co., 218 West Commerce, will receive bids after Dec. 13 for the construction of a cold storage plant. Estimated cost including equipment $30,000.

Tex., San Antonio—Travis Investment Co., c/o R. C. Hill, Travis St., awarded contract for the construction of a 21 story office building at Travis and Soledad Sts. to Lon T. Wright & Co., 910 Builders Exchange Bldg. Estimated cost $2,000,000. Refrigeration system for circulating ice water, 5 elevators, etc. will be installed.

Wis., Chippewa Falls—Northern States Power Co., 15 South 5th St., Minneapolis, Minn., plans the construction of a hydro-electric plant and dam on Chippewa River. Estimated cost approximately $3,000,000. Byllesby Engineering & Management Co., 231 South La Salle St., Chicago, Ill., is engineer.

Wis., Milwaukee—Schroeder Hotel Co., 86 Michigan St., will soon award contract for the construction of a 23 story hotel on Grand Ave. Estimated cost $4,000,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Ill. are architects.

Wis., Sheboygan — Sheboygan Mattress Co., 9th and South Water Sts., is having plans prepared for the construction of a factory on Saeman Ave. E. A. Juul, Security National Bank Bldg., is architect. Electric motors will be required.

Wis., Soldiers Grove—Interstate Power Co., H. C. Ortin, Mgr., Dubuque, Ia., plans the construction of a dam here. Estimated cost $25,000. Engineer not selected.

Ont., Toronto — Toronto East General Hospital Association, 133 Danforth Ave., plans the construction of a 3 or 4 story hospital including steam heating and ventilation systems, elevators, etc. at Danforth and Greenwood Aves. Estimated cost $900,000. J. J. Woolnough, City Hall, is architect.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

SUBSTANTIAL declines occurred during the month in air, water and steam hose; linseed oil; flexible cord; and armored cable, No. 14 solid.

Firmness with upward tendencies in price, developed in high grade babbitt metal and rubber-covered copper wire.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 68c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	50%

Air—Best grade

¾-in., per ft.	3-ply	$0.34	4 ply	$0.42

Steam—Discounts from List

First grade	40%	Second grade	40–5%	Third grade	50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING—For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ½ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	13.00@17.50	18.00	15.00@20.00
Colored	10.00@14.00	13.50	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.17½
Cleveland (per thousand)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.86½	$0.98	$0.84

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.75	$16.75	$17.25
White	15.25	15.75	15.25	15.75

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅞x1-in. and longer, 19c. per lb., less 50% at New York warehouses Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, per 100 lb.:

New York	$4.20	Chicago	$3.50	Pittsburgh	$2.50@2.60

Cone-head boiler rivets, per 100 lb.:

New York	$4.40	Chicago	$3.70	Pittsburgh	$2.90

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick: 9-in. straights	net ton	65.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick: Soaps and spits	per ton	91.00
Silica brick: Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@45
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per M	33@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	38@40
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	38@40
Clay brick, 2nd quality 9 in. shapes, Maryland	per M	38@40
Chrome ore crude, 40@50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	90.00
Commercial genuine, intermediate grade	63.00
Anti-friction metal, general service	32.50
No. 4 babbitt (f.o.b.)	14.00

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	12

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	
2½ to 4	57	46½	2½ to 4	29	
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	
9 and 10	45	32½	9 to 12	16	
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25.00	20.24
2¼	19.84	28.25	23.00
2½	21.60	34.00	26.03
3	25.50	42.50	27.04
3½	30.25	49.50	30.67
3¾	31.50	52.75	33.33
4	38.03	67.00	40.11

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$32.00 (net)	$ 51.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:	Lead Covered
Less than coil lots 50%	20%
Coils to 1,000 ft 60%	30%
1,000 to 5,000 ft 60–5%	35%
5,000 ft. and over 60–10%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15.10	17.21	8.39	9.13
¾	139.77	152.88	20.51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224.85	245.94	50.13	56.40	19.41	21.01
1½	355.50	388.85	82.03	92.28	27.73	30.01
2	464.88	508.50	218.74	246.10	41.59	45.01
2½	585.30	637.74	483.04	543.46	55.46	60.02
3	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$18.50
No. 16 cotton reinforced heavy		23.50
No. 18 cotton reinforced light		16.00
No. 16 cotton reinforced light		20.50
No. 18 cotton Canvasite cord		15.50
No. 16 cotton Canvasite cord		19.00
No. 16 super service cord or similar (2 wire) in 1,000 ft	$92.00	*101.20
No. 14 super service cord or similar (2 wire) in 1,000 ft	133.00	*146.40

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each
15	A 17	$0.25
General		
25	A 19	.25
40	A 21	.25
50	A 21	.27
60	A 21	.30
100	A 23	.43

200—260 Volt Watts	Type	Price Each
Special		
25	A 19	$0.30
50	A 21	.30
100	A 23	.53

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.60	$9.75	$11.60	$18.20
12	10.10	12.60	14.60	23.80
10	13.20	16.40	18.60	30.50
8	19.00	22.30	24.20	42.40
6	.....	.....	34.40	.....
4	.....	.....	48.00	.....
2	.....	.....	68.75	.....
1	.....	.....	94.70	.....
0	.....	.....	115.00	.....
00	.....	.....	138.00	.....
000	.....	.....	165.00	.....
0000	.....	.....	196.00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Key	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 29c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.0 list value	30–5%
$50.00 list value or over	35%